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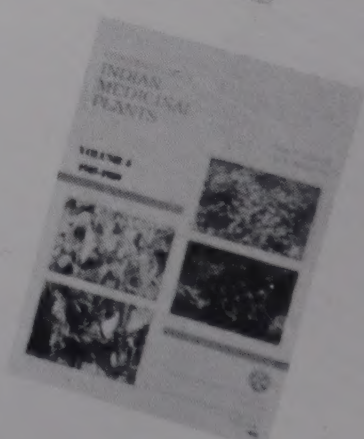
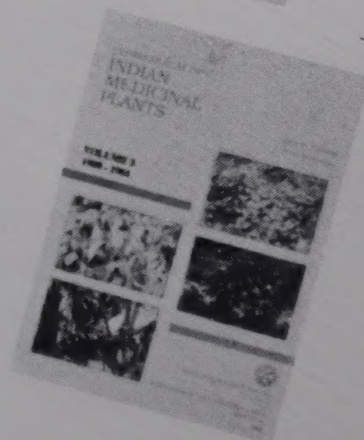
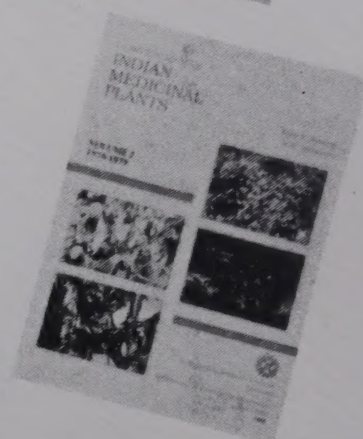
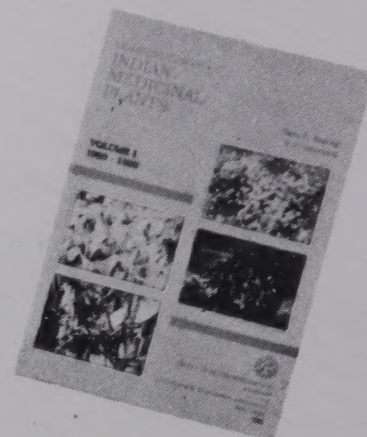
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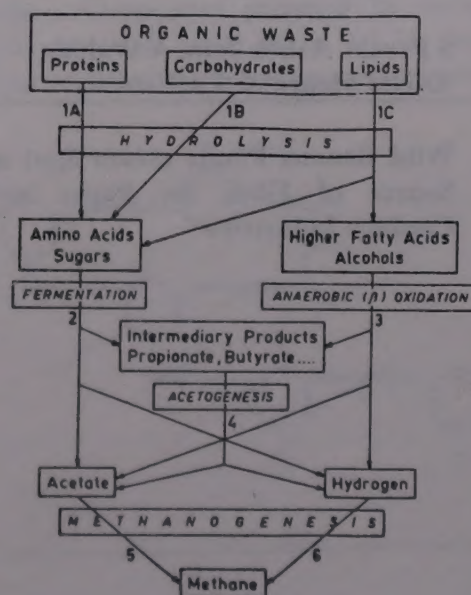
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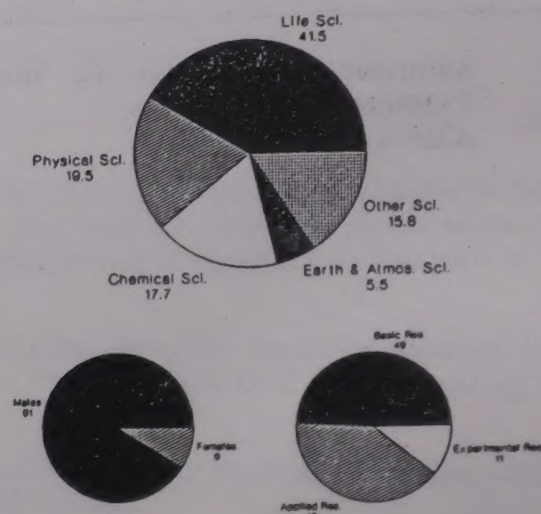
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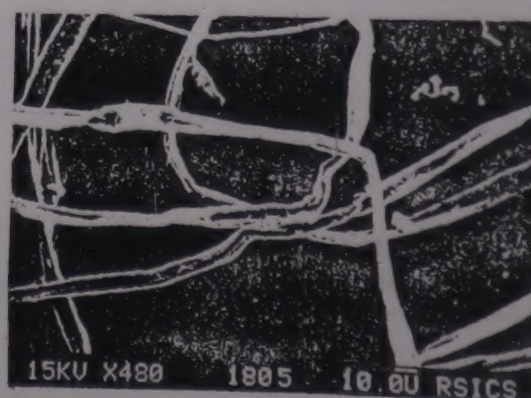
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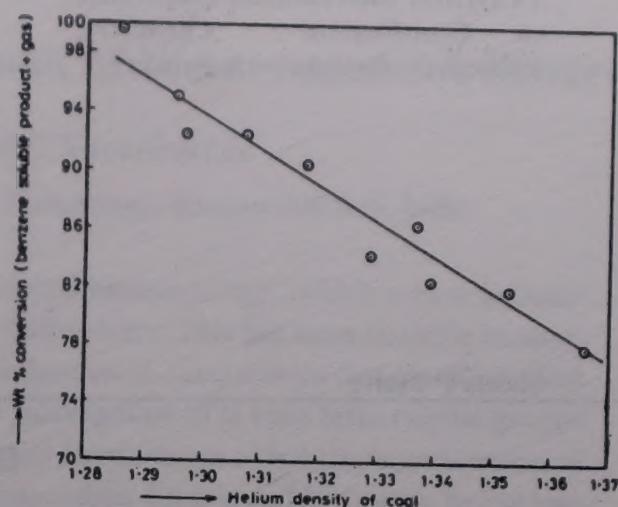
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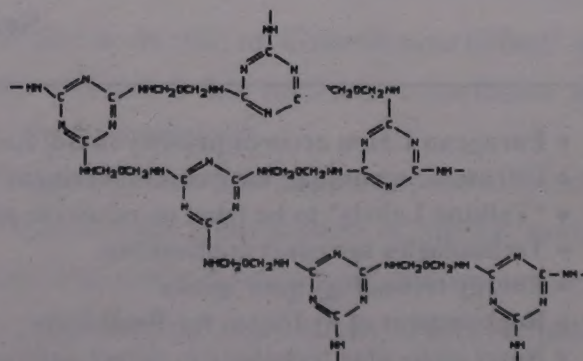
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Anaerobic Biotechnology for the Treatment of Wastewaters: A Review

Grasius M G, Leela Iyengar* and C Venkobachar

Department of Civil Engineering, Indian Institute of Technology, Kanpur 208 016, India

Anaerobic biomethanation is an emerging field of environmental biotechnology, which is now increasingly being used for the treatment of domestic and industrial wastewaters. This has been possible because of a better understanding of the microbial consortia and the introduction of novel reactor designs. Biological methane formation is a complex process involving coordinate participation of at least three trophic groups of bacteria. Major biochemical transformations are hydrolysis and fermentation of polymers, conversion of fermentation products to acetate and formation of methane from carbon dioxide and hydrogen. In last two decades, several reactor configurations have been developed to retain slow growing anaerobic microorganisms in the reactor which have led to the application of this technology for the treatment of dilute as well as concentrated wastewaters. In India, under *Ganga Action Plan*, domestic wastewater treatment using this technology has been initiated in at least two cities of Uttar Pradesh. In this paper, microbial and biochemical aspects, environmental factors affecting this process as well as different reactor configurations used for anaerobic treatment of wastewaters are briefly discussed.

Introduction

Application of anaerobic biotechnology for the treatment of industrial as well as domestic wastewaters leading to methanogenesis is now attracting worldwide attention. This is mainly because of several advantages of anaerobic biological process as compared to traditional aerobic treatment methods, which include low sludge production and nutrient requirements as well as the production of useful byproduct in the form of methane. Methane is produced in the environment, when organic material is degraded by microorganisms in the absence of oxygen, nitrate and sulphate¹. It has been estimated that about 500-800 billion tonnes of biogenic methane is released into atmosphere every year². Intensive rice paddy cultivation, which provides the required environment for methane forming microorganisms and livestock have been identified as important contributors to biogenic methane. It has been reported that microbes present in the rumen of cow can lead to the production of 200 or more litres of methane per day, which is removed from the system by belching³. Recent concern for biogenic methane generation in

nature is due to its role in 'Greenhouse Effect' and it has been estimated that methane contributes about 18% to global warming⁴.

Although anaerobic treatment provided a technological solution for stabilization of animal manures and municipal sludges since long, the earlier reactor designs precluded the application of this technology to industrial and domestic wastewaters. These reactor designs were using suspended microbial system which required a lengthy detention time of the waste within the reactor, thus necessitating a very large reactor volume. Introduction of novel reactor designs and better understanding of anaerobic microbiology have now led to the application of anaerobic biotechnology for the treatment of these wastewaters worldwide. It is considered as the method of choice in India for the treatment of domestic wastewaters, after the performance evaluation of a demonstration plant at Kanpur⁵. It has to be mentioned that a combined anaerobic plant for domestic and tannery wastewater which is first of its kind in the world, has also been installed recently in Kanpur under *Ganga Action Plan* ⁶.

*Department of Chemistry

This paper deals briefly with various aspects of anaerobic biotechnology which includes microbiology, biochemistry, environmental factors affecting the process as well as different reactor configurations used for the treatment of domestic and industrial wastewaters.

1 Microbiology and Biochemistry of Anaerobic Process

Biological conversion of complex organics present in wastewaters to CO_2 and CH_4 requires the coordinate participation of three different trophic groups of bacteria, namely hydrolytic and acidogenic bacteria, obligate hydrogen producing acetogenic bacteria (OHAB) and methanogenic bacteria. Six distinct biochemical steps involved in this conversion are: (i) Hydrolysis of polymers, i.e. carbohydrates, fats and proteins to their monomeric forms such as sugars, fatty acids and amino acids, (ii) Fermentation of amino acids and sugars leading to the formation of short chain fatty acids and alcohols, (iii) Anaerobic oxidation of long chain fatty acids, (iv) Anaerobic oxidation of intermediary metabolites like volatile fatty acids and alcohols (formed from sugars and amino acids) to acetate, (v) Conversion of acetate to methane and (vi) Conversion of hydrogen and CO_2 to methane⁷. The anaerobic pathway for organic stabilization is presented in Fig. 1. The first two steps are carried out by hydrolytic and acidogenic bacteria. Anaerobic oxidation of long chain fatty acids and intermediary metabolites are mediated by a second group of trophic microorganisms, which are collectively termed as OHAB. Methanogenic bacteria synthesize methane from acetate as well as CO_2 and H_2 .

1.1 Hydrolytic and Acidogenic Bacteria

Organic polymers have to be solubilized before they can enter the bacterial cell. This process of solubilization is brought about by exocellular enzymes excreted by hydrolytic and acidogenic bacteria, which hydrolyse complex carbohydrates, proteins and fats to simple sugars, amino acids, glycerol and fatty acids. The solubilization of complex organics is a crucial step in methanogenesis of suspended organics present in wastewater. Different types of polymers are degraded at different rates. Based on the kinetic studies, Paviostathis and Giraldo-Gomez⁸ have concluded that among proteins,

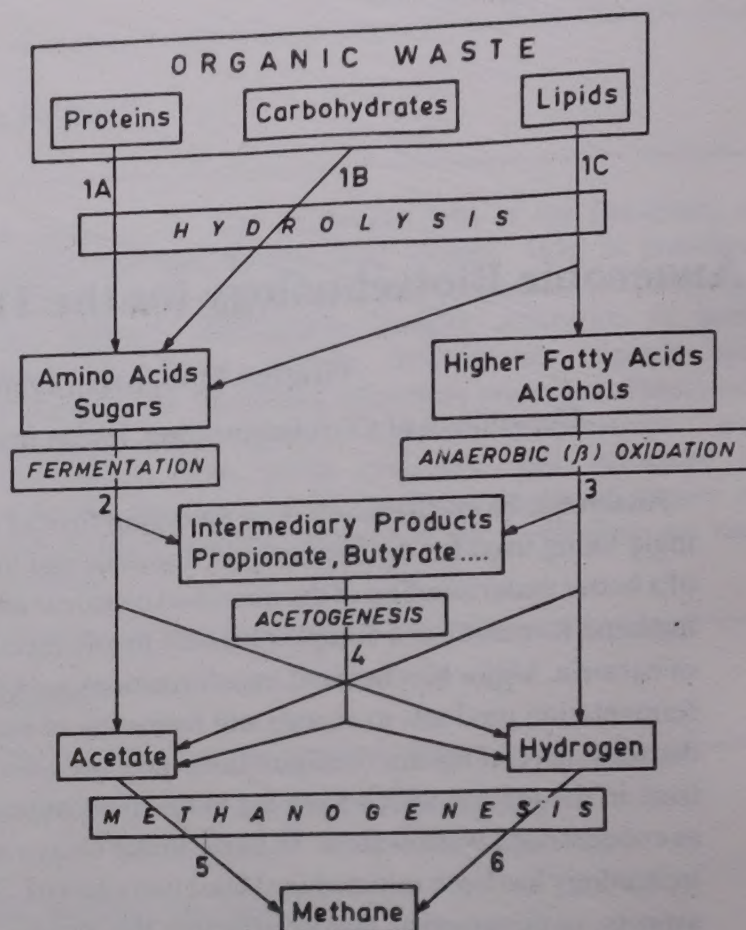


Fig.1 — Pathway of anaerobic biodegradation

carbohydrates and fats, the hydrolysis of particulate protein is the major rate limiting step in the anaerobic digestion of biological sludge.

Products formed from the hydrolysis of polymers are converted to intermediary metabolites like butyrate, pyruvate, ethanol, acetate etc. by bacterial fermentation. Fermentation can be described as biological process in which organic compounds serve as electron donors and electron acceptors⁷. Pyruvate occupies a central position in the degradative pathway of sugars, amino acids and glycerol (Fig. 2). Major bacterial genera taking part in this process have been identified as facultative anaerobes like *Streptococci* and *Enterobacteriaceae* as well as strict anaerobes like *Clostridia* and *Bifidobacteria*⁹. Facultative anaerobes, apart from taking part in the production of intermediary metabolites, also play a key role in the anaerobic microbial ecology. They utilize oxygen, which may be present in the wastewater, thus leading to the conducive environment required for the fastidious anaerobic methanogenic bacteria⁹.

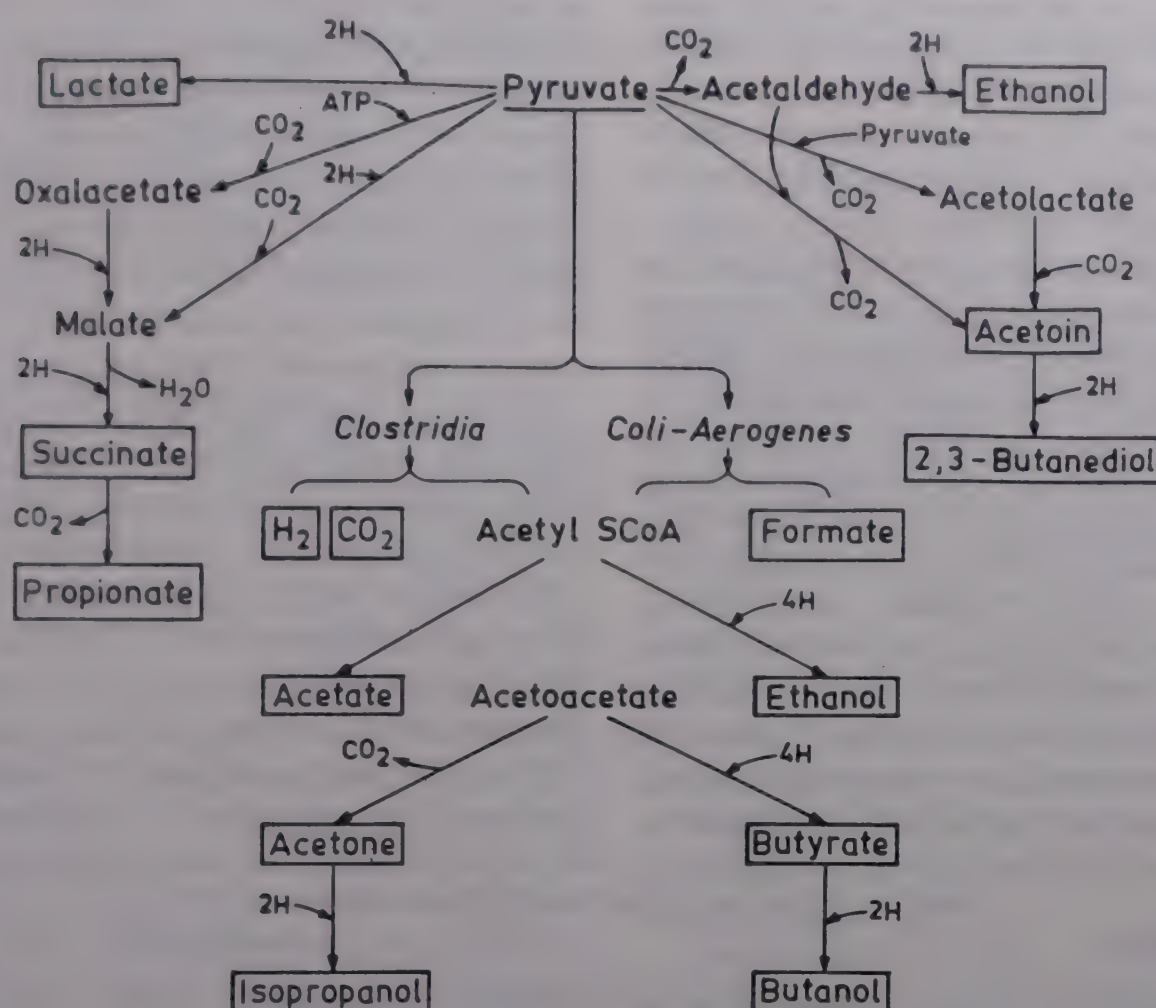


Fig.2 — Bacterial fermentation products of pyruvate

1.2 Obligate Hydrogen Producing Acetogenic Bacteria (OHAB)

The second group of trophic organisms involved in the anaerobic stabilization of organics are OHAB, also termed as syntrophic acetogenic bacteria, as an obligate syntrophic (syn-together trophic-eat) relationship exists between this group and H_2 utilizing microorganisms. The existence of this group of microorganisms was first reported by Bryant *et al.*¹⁰ in 1967 and now their role in organic degradation leading to methane formation is well established^{11,12}. This group mediates the anaerobic oxidation of long chain fatty acids and intermediary metabolites.

Degradation of long chain fatty acids formed from the hydrolysis of fats is through β -oxidation¹³, which is termed as anaerobic oxidation. This is a cyclic process releasing one acetate unit per cycle and end products produced are either acetate or acetate and propionate depending on whether the fatty acids are even or odd carbon acids. Proton is the main electron acceptor during this oxidation leading to H_2 formation.

Products formed during anaerobic oxidation of intermediary metabolites are acetate and hydrogen^{14,15}. For the efficient degradation of fatty acids, removal of H_2 is essential as thermodynamically all the reactions catalyzed by this group of microorganisms are endergonic [Table 1, Eqs (1-4)]. Thus the equilibrium shift tends towards left and the organisms are unable to utilize organic substrates, unless H_2 is removed immediately. Hence a simultaneous transfer of electrons to H_2 utilizing microorganisms such as methanogens is absolutely essential for the growth of acetogens. Propionate oxidation can occur only when the partial pressure of H_2 is below 10^{-6} bars¹⁶. This low H_2 pressure can only be maintained by an intensive cell contact between acetogenic and methanogenic bacteria¹⁷. This process, termed as inter-species electron or H_2 transfer, is a crucial step in anaerobic biotechnology.

Recently, formate has been identified as key intermediary metabolite in controlling syntrophic methanogenesis¹⁸. Its mode of formation from pyruvate can be either in the presence of pyruvate lyase

[Table 1, Eq.(10)] or ferridoxin-CO₂ oxido reductase [Table 1, Eq.(11 and 12)]. Latter pathway has been identified as the major route for formate production, where this becomes an electron sink end product during regeneration of reduced ferridoxin in bacteria lacking hydrogenase [Eq.(13)].

It has been reported that many methanogens can utilize formate as carbon source². The first experimental evidence on the role of formate as an important extracellular intermediate in the conversion of ethanol to methane, was reported by Thiele and Zeikus²⁰. They proposed that bicarbonate accepts the electrons during ethanol conversion to acetate by syntrophic acetogens leading to the formation of electron sink product, formate, which is subsequently utilized by methanogens to form methane. Recent studies of Boone *et al.*²¹, which are based on diffusion of H₂ and formate, have also showed that inter-species formate transfer may be the predominant mode of electron transfer between syntrophic

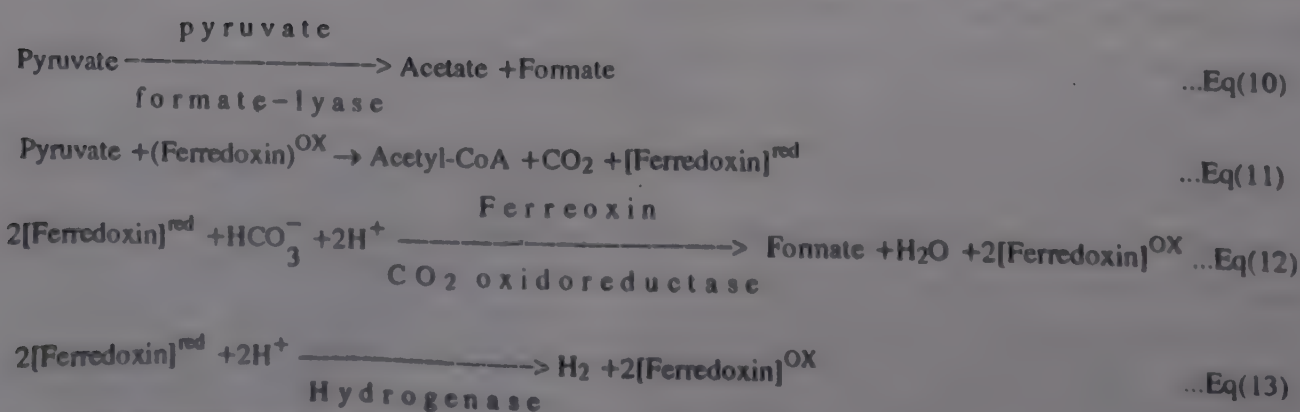
acetogens and methanogens. Gorbicki and Stuckey¹⁹ have reported the appearance of very high levels of formate in anaerobic reactors during shock loading followed by a rapid recovery indicating an unusual stability. They propose that it may be desirable to encourage formate production through reactor design or environmental conditions. However, more work is needed to envisage the role of formate in anaerobic degradation of different wastewaters.

Syntrophic acetogens have not been physiologically well characterized. Among the two reported organisms of this group, *Syntrophomonas wolinii* is a versatile anaerobic bacteria capable of converting C₄-C₈ fatty acids to acetate and propionate using β -oxidation process¹². The generation time of this organism on butyrate is about three days. *Syntrophomonas wolinii*, a slow growing bacteria with a generation time of about 7 d, can utilize only propionate and crotonate as its substrate¹¹. Since

Table 1(a) — Reactions catalysed by OHAB and methanogens

Reaction	ΔG° /reaction (kJ)
$\text{CH}_3\text{CH}_2\text{COO}^- + 3\text{H}_2\text{O} \rightarrow \text{CH}_3\text{COO}^- + \text{H}^+ + \text{HCO}_3^- + 3\text{H}_2$	+76.1 ...Eq(1)
$\text{CH}_3\text{CH}_2\text{CH}_2\text{COO}^- + 2\text{H}_2\text{O} \rightarrow 2\text{CH}_3\text{COO}^- + \text{H}^+ + 2\text{H}_2$	+48.1 ...Eq(2)
$\text{CH}_3\text{CH}_2\text{OH} + \text{H}_2\text{O} \rightarrow \text{CH}_3\text{COO}^- + \text{H}^+ + 2\text{H}_2$	+9.6 ...Eq(3)
$\text{CH}_3\text{CHOHCOO}^- + 2\text{H}_2\text{O} \rightarrow \text{CH}_3\text{COO}^- + \text{HCO}_3^- + \text{H}^+ + 2\text{H}_2$	-4.2 ...Eq(4)
$4\text{H}_2 + \text{CO}_2 \rightarrow \text{CH}_4 + 2\text{H}_2\text{O}$	-138.8 ...Eq(5)
$4\text{HCOOH} \rightarrow \text{CH}_4 + 3\text{CO}_2 + 2\text{H}_2\text{O}$	-119.5 ...Eq(6)
$\text{CH}_3\text{COOH} \rightarrow \text{CH}_4 + \text{CO}_2$	-27.6 ...Eq(7)
$4\text{CH}_3\text{OH} \rightarrow 3\text{CH}_4 + \text{CO}_2 + 2\text{H}_2\text{O}$	-310.5 ...Eq(8)
$4\text{CH}_3\text{NH}_3^+ + 2\text{H}_2\text{O} \rightarrow 3\text{CH}_4 + \text{CO}_2 + 4\text{NH}_4^+$	-225.7 ...Eq(9)

Table 1(b) — Reactions leading to formate production



crotonate is unlikely to occur in anaerobic digester propionate is the only available substrate for these organisms. Thus, population of *S. wolinii* may be limited in stable anaerobic digesters. This leads to the accumulation of propionate in digester during organic overloading, which is taken as an indicator for stressed conditions.

1.3 Methanogenic Bacteria

They represent the terminal trophic group of bacteria required for the biomethanation of organic carbon. Methane is formed through decarboxylation of acetate as well as by the reduction of CO_2 by H_2 . Methane formers are strict anaerobes and require a redox potential of -300 mV, which corresponds to one molecule of oxygen per 10^{56} litres of water². Although, oxygen is the potential inhibitor of methane formation, methanogens are not killed when exposed to oxygen. They survive and proliferate when environmental conditions allow them to do so.

Methane is produced by bacteria using substrates H_2/CO_2 , formate, methanol, methylamines and acetate^{22,23}. Energy yielding reactions for methanogens are given in [Table 1, Eqs. (5-9)]. Immunological techniques, apart from conventional approach like taxonomic, physiologic and gram staining, have been used to characterize methanogens^{24,25}. Forty-three species of methanogens have been identified using antigenic fingerprinting and antibody probes. Of these, all except methanotrix species, can utilize H_2/CO_2 as substrate for methane formation. Nineteen species can utilize formate. These two reactions are thermodynamically most favourable²². Although very few species degrade acetate to CH_4 and CO_2 , 70% methane generated in anaerobic digesters originate from methyl group of acetate. *Methanosarcina barkeri*, *Methanosarcina vacuolata*, *Methanococcus mazei* and *Methanotrix soehgenii* are major acetoclastic bacteria, which have been isolated as pure cultures². *M. barkeri* and *M. mazei* are more versatile as they can utilize methylamine and methanol as carbon source in addition to acetate and CO_2 . Among the acetate cleaving methanogens, *M. barkeri* grows much faster with a generation time of 2-3 d, but has a saturation substrate concentration (K_s) of 5 mM L^{-1} for acetate. On the other hand, *M. soehgenii* has a generation time of 10 d or more, but has a relatively low K_s value of 0.7 mM L^{-1} . Thus it can outcompete other methanogenic strains at longer

detention times, which are generally achieved in high rate anaerobic reactors².

Methanogens differ from other bacteria in several biochemical characteristics². Muramic acid, a characteristic cell wall component of bacteria, is absent in methanogens. Composition of lipids also differs markedly from that of other typical procaryotes. Coenzyme M, coenzymes F_{420} and F_{430} are found only in methanogens². These characteristics had led to the classification of methanogens as members of archaebacteria, which is an ancient group and phylogenitically different from procaryotes. Recent report on the genome of thermophilic *Methanococcus janaschii* has also supported this proposition²⁶. Complete genome of *M. janaschii* consisting of 1.7 billion base pairs has been decoded and majority of the genes do not have equivalent in other organisms whose genes are deposited in public database. Other members of archaebacteria are extreme halophiles and thermoacidophiles.

The formation of methane, the most reduced form of carbon, from CO_2 probably requires four reduction steps involving the oxidation levels of formate, formaldehyde and methanol (Fig. 3). These intermediates have not been isolated in free form and thus appear to be bound to different carriers during the reduction process². No respiratory electron chain has been identified in methane bacteria till now.

Sulphate reducing bacteria (SRB) can partially or completely mineralize the fermentation products to Hydrogen sulphide and CO_2 via sulphate reduction if sulphate is present in the wastewaters²⁷⁻³¹. H_2S thus formed is toxic to methanogens. Thus SRB play a dominant role in anaerobic digester stability. Some species can also function as syntrophic acetogens, especially in the case of ethanol degradation. The role of SRB in anaerobic methanogenesis has been summarized as follows³²:

- (a) Generates sulphide that may lead to enhancement in growth of or toxicity to methanogens depending on the concentration,
- (b) Increases the reactor pH, which is favourable for methanogens,
- (c) Competes with methanogens for acetate and H_2 , and

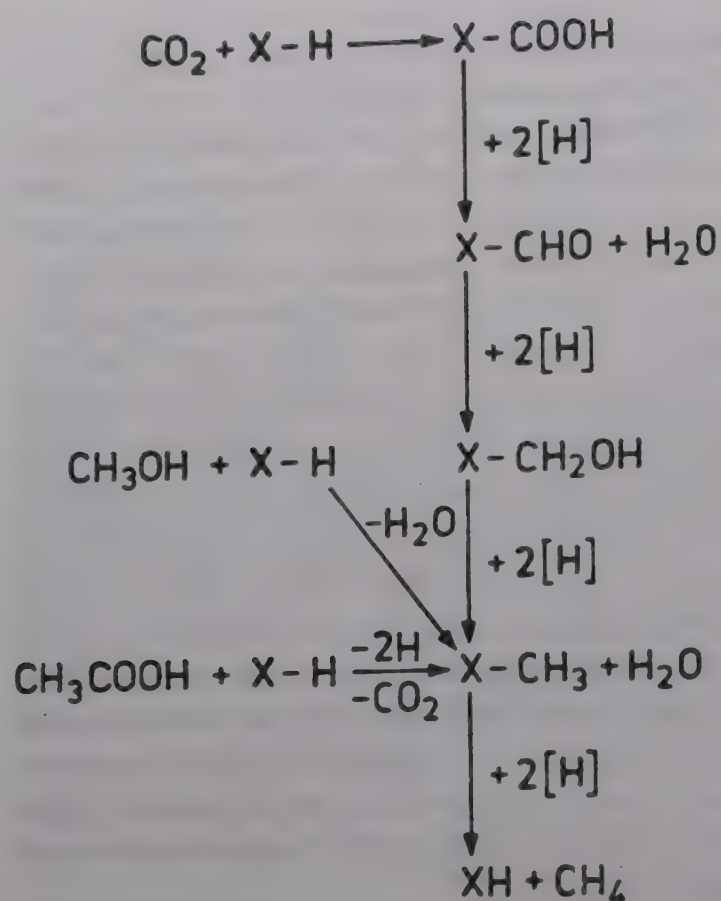


Fig. 3 — Tentative scheme for the reduction of carbon dioxide to methane³ (X represents one or more coenzyme species which act as C carriers)

(d) At low sulphate concentrations, members of the genus *Desulfovibrio* can act as syntrophic acetogens in the conversion of ethanol to methane³³.

From the above brief discussion on microbiology/biochemistry of anaerobic methanogenesis, it can be seen that stabilization of organics is a complicated microbial process, involving many consecutive, parallel and interdependent reactions. Among the three trophic bacteria, acid formers represent rapidly growing group with generation time of 6-16 h³⁴. Both acetogenic and acetoclastic methane formers have a doubling time ranging from 2- 10 d^{11,12}. Hydrogen utilizing methanogens have shorter generation time as compared to acetoclastic methanogens as thermodynamically this reaction is more favourable²². Thus acetoclastic methanogens, which lead to the production of 70% methane in anaerobic digesters are the bottleneck organisms in the stabilization of soluble organics. However, particulate organics require liquefaction (or hydrolysis) to render these substrates available to the anaerobic microflora. Studies on the kinetics of hydrolysis has

shown that this to be the limiting-step in the overall conversion of complex substrates to methane⁸.

Propionate tends to accumulate in the digesters during overloading of soluble organics and is difficult to remove during recovery as its degradation to acetate is thermodynamically infeasible unless the product, hydrogen, is removed by H₂ consuming methanogens. Thus the harmony between propionate oxidation, acetate decarboxylation and H₂ oxidation is crucial for anaerobic process stability⁷. Thiele and Zeikus²⁰ have proposed that the close physical association or juxtapositioning of acetogens and H₂ consumers within anaerobic granule enhances the inter-species electron transfer efficiency. Recent studies on the ultrastructure of anaerobic granules using transmission and scanning electron microscopy have confirmed this proposition³⁵⁻³⁷. Further these authors have reported that the increased efficiency of retained biomass reactors can be attributed not only to the higher microbial concentration but also due to the different juxtapositioning of trophic microbial groups in a granule or biofilm.

2 Factors Affecting Anaerobic Organic Stabilization

Anaerobic digestion is affected by many factors among which, temperature, pH, nutrients and presence of toxicants/inhibitors in the wastewater to be treated, are the most important. They profoundly affect the microbial growth rate thereby affecting substrate utilization and overall efficiency of treatment.

2.1 Temperature

Effect of temperature on the rate of anaerobic digestion dictates that this should be considered as the principal design parameter. Methanogenesis rate with suspended microbial system gradually increases from 25 °C with an optimum between 35- 40°C beyond which, a decrease is observed as methane formers grow best in mesophilic temperature range³. Very few species belong to thermophilic range. Further, excess energy required to maintain the reactor at 20-30°C above ambient temperature is the major drawback of using thermophilic range for anaerobic waste stabilization. Thus the mesophilic range is used extensively in practice for the treatment of sewage sludges as well as domestic and industrial

wastewaters. With retained biomass reactors, start-up will be prolonged at lower temperatures ($<25^{\circ}\text{C}$). However, once developed, they may be operated at low temperatures⁹. Rapid alterations in temperature, even by few degrees, can result in a marked effect on microbial metabolism and may require several days for recovery. Inefficiencies of climatically heated small anaerobic digesters can be ascribed to diurnal temperature fluctuations. The change in operating temperature especially towards lower side, if it is required, should be effected gradually. This permits the microbial adaptation to the new temperature. It is observed that slow growing methanogenic bacteria adapt slowly to changed temperature conditions as compared to other groups present in anaerobic digesters. This results in rapid accumulation of volatile acid intermediates, which are inhibitory to methanogen leading to process failure.

2.2 pH and Alkalinity

Optimum pH range for methanogenesis has been reported to be between 6.8 and 7.4. Low pH are particularly detrimental to methanogens than fermentative bacteria. Important buffering system present in anaerobic reactors is bicarbonate although ammonia may be predominant in the digestion of sludge and treatment of protein rich wastewaters. Under stable operating conditions, HCO_3^- levels are decreased in the acidogenic phase and are released during methanogenesis. However, during overloading, formation of high concentrations of volatile acids as well as subsequent inhibition of methanogenesis cause the decrease in pH. As the fermenting bacteria can continue to produce fatty acids despite pH depression, the environmental conditions further deteriorates and thus leading to the situation of 'Stuck digesters'. For the optimum performance of anaerobic digesters, ratio of volatile fatty acids to total alkalinity should be maintained around 0.1. Addition of alkalinity in the form of lime or NaHCO_3 may be required during the treatment of some industrial wastewaters. It is to be mentioned that pH adjustment alone cannot revive the performance of stuck digesters. A fresh active biomass addition may also be required.

2.3 Nutrients

Apart from organic carbon source, anaerobic microorganisms require nitrogen, phosphorous, and other trace elements for cell synthesis. While domestic wastewater may contain all these components in required quantities, many industrial wastewaters lack some of them and thus have to be supplemented. The theoretical minimum COD/N/P ratio required for high loaded anaerobic process (0.8-1.2 g COD/g VSS.d) is around 400/7/1. For low loaded digesters, COD/N ratio increases dramatically to 1000/7³⁴. Four elements, iron, cobalt, nickel and sulphur have been shown to be essential nutrients for anaerobic consortia especially for methanogens³⁸⁻⁴⁰. Addition of iron and cobalt salts enhanced methane production even from domestic wastewater sludges and cattle manure which are generally assumed to be nutritionally adequate. Ni is a component of coenzyme F_{430} present specifically in methanogens. Although high levels of sulphide adversely affect methane production, it is an essential nutrient for methanogen³⁸. Unionised H_2S concentration required for optimal growth of methanogens is 13 mg/L and this corresponds approximately to 0.5% H_2S in the head gas at equilibrium. It has been reported that sulphur content of methanogens is of the same magnitude as that of phosphorus and is in the range of 5-12 mg/dry weight³⁹. Apart from these trace elements, some acetogenic bacteria and *Methanococcus* have been reported to be requiring molybdenum, selenium and tungsten⁹.

Inhibition and Toxicity

It is generally observed that acetogens and methanogens are more sensitive to the presence of inhibitors as compared to fermentative bacteria. Inhibitors can be broadly categorized into three groups. First group consists of toxic compounds present in wastewater. This includes heavy metal ions, pharmaceuticals, insecticides, sulphates and organic solvents. Toxicity of any specific compound to methanogenesis can be evaluated using anaerobic toxicity assay⁴¹. It is generally determined with reference to methanogens and acetogens, which degrade acetate and propionate respectively. The active inoculum sludge is spiked with acetate or propionate and gas production in the presence of a compound or ion as compared to the control, indicates inhibition. Using this procedure, Parkins *et al.*⁴², have deter-

mined the threshold levels of a variety of industrial toxicants beyond which methanogenic consortia is inhibited. However, it may be mentioned that methanogenic consortia have exhibited a significant potential to acclimate to many toxicants and even biodegrade them⁴³.

Second group consists of components, which are essentially required in low concentrations, but toxic at higher concentrations^{28,29,44,45}. Sulphide is one such example. Sulphate, when present in wastewaters, is reduced to sulphide in anaerobic digesters. Sulphate itself, is not inhibitory to methanogens even at very high concentrations. However, sulphide formed by the reduction of sulphate by SRB leads to the decrease of methane formation due to its toxic effect on methanogens⁴⁵. As mentioned earlier, sulphide is an essential nutrient for methanogens. However, when the concentration increases beyond certain critical level, inhibition of methanogenesis is observed. Inhibition of sulphide is pH dependent as only unassociated H_2S is toxic to methanogens⁴⁶.

Third group consists of obligate metabolic intermediates of the process acting as inhibitors at high concentrations. Propionate and butyrate are intermediary metabolites in the anaerobic degradation of organics, which are inhibitory at high concentrations. In an efficiently operating anaerobic system, where partial pressure of H_2 is maintained at very low level, formation and degradation of these volatile acids are well balanced. Overloading, decrease in hydraulic detention time or abrupt changes in temperature results in a stress on slow growing methane formers and leads to a rapid accumulation of volatile fatty acids. They are potential inhibitors of methane formers. Although the mechanism of inhibition is still obscure, unassociated volatile fatty acids seem to play an important role and thus the extent of inhibition is pH dependent. Propionate has been reported to be the most toxic among three volatile fatty acids to H_2 utilizing methanogens⁹. This inhibition, in turn, results in an increase in H_2 partial pressure of the system leading to the inhibition of acetogenic bacteria. Thus the accumulation of volatile fatty acids ultimately results in 'Stuck digesters'.

3 High Rate Anaerobic Reactors

Despite the well recognized advantages of anaerobic biological process, its application was restricted to the treatment of concentrated wastes such as ani-

mal refuse and the sludge derived from aerobic treatment processes. This was mainly due to the reactor design which employed suspended microbial system, where microorganisms were removed from the reactor along with the treated effluent. This necessitated a long residence time of even up to 20-30 d so as to keep high concentrations of the slow growing acetogenic and methane bacteria in the reactor, thus demanding a large volume reactors. This restricted the process application to industrial and domestic wastewater treatment.

During last two to three decades, high rate reactor types which separate hydraulic retention time (HRT) from biological sludge retention time (BSRT) and allow the slow growing anaerobic bacteria to be retained within the reactor independent of wastewater flow, have been developed⁴⁷. Most of these high rate systems are essentially retained biomass system, where microorganisms are present in the reactor as an attached biofilm grown on a support medium or as flocs/granules which are easily separable from aqueous phase. Using these reactor designs, it has been possible to operate the reactors at higher organic loading rates and at low HRTs. Increased efficiency of these reactor configurations can be attributed to higher biomass concentration as well as juxtapositioning of different trophic microbial groups in a biofilm or granule resulting in better specific waste stabilization capacity¹⁷. The introduction of these reactor designs has now made the application of anaerobic biotechnology to high strength organic wastewaters.

Figure 4 shows different configurations of high rate anaerobic wastewater treatment systems. Some of their salient features are briefly discussed here.

3.1 Anaerobic Contact Process

This was one of the first retained biomass reactor configuration to be introduced^{48,49}. In this system, microbial flocs are separated from treated effluent in an external gravity or centrifugal separating device and returned to the reactor. This is sometimes referred to as anaerobic activated sludge. Settability of the microbial flocs depends upon waste characteristics and the loading rate. Higher loading rate may cause the buoyancy in the floc leading to poor settling. Degassification may become necessary in some instances². Thus the process has a build-in maximum loading rate. The reactor design

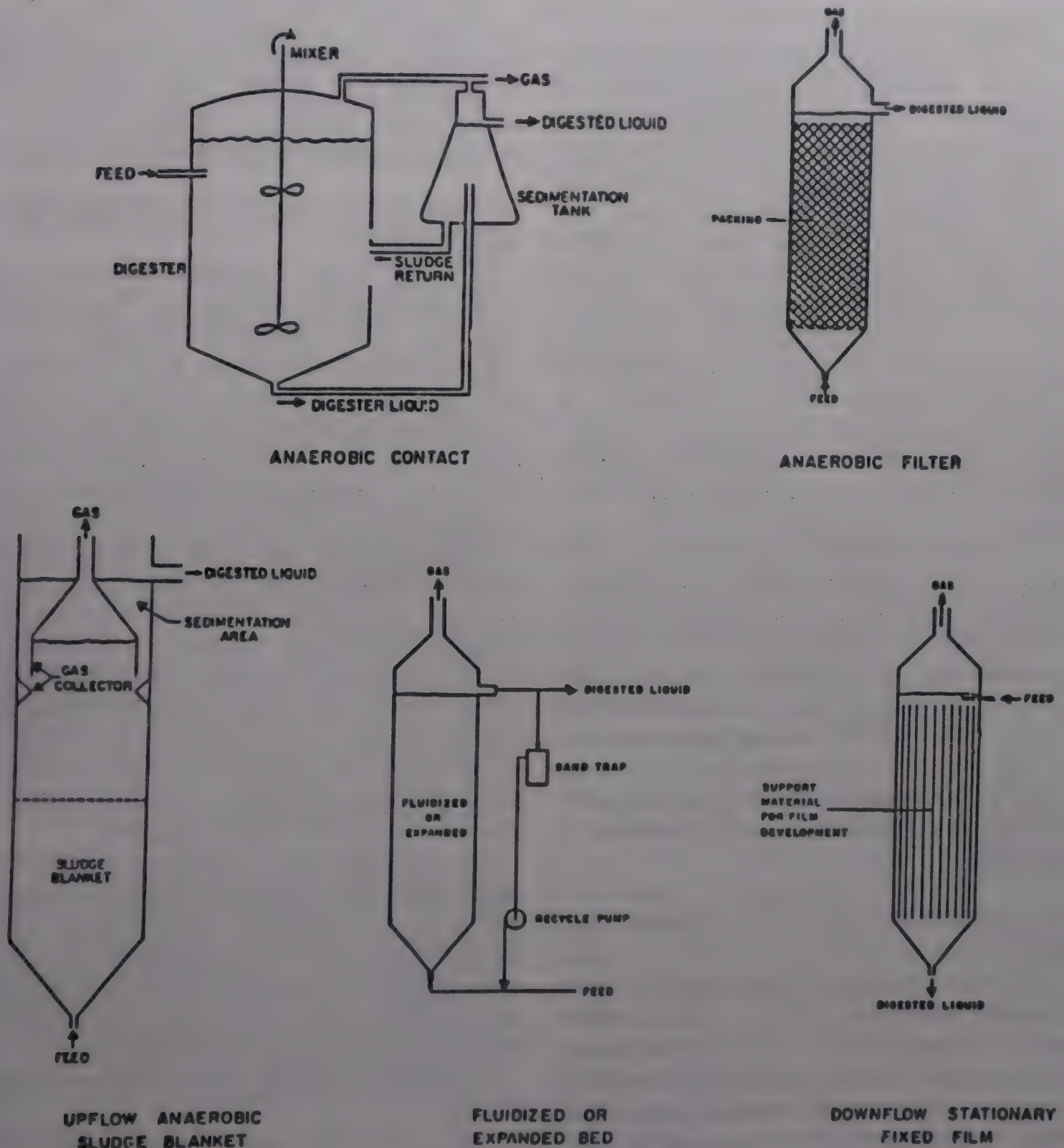


Fig.4 — Various high rate anaerobic reactor systems

is especially suited for wastes having a certain amount of hard-to-digest solids that settle readily or attach themselves to settleable solids. These solids

will then have a detention times well in excess of HRT and thus have a chance to be degraded⁵⁰. The process is not affected by substrate diffusion limita-

tion as mixing is provided in the reactor. However, the retained biomass concentration is comparatively less, thus limiting the loading rate.

3.2 Anaerobic Filter (AF)

The anaerobic filter was introduced by Young and McCarty⁵¹, in 1969, on the basis of earlier work by Coulter *et al.*⁴⁸. Inert support materials in the form of sheets, rings and spheres are provided in the reactor either in random or ordered configuration for microbial attachment and biofilm development. The reactor may be operated in the upflow or downflow mode. Suspended microorganisms tend to collect at the bottom of the reactor. The process is suitable for dilute as well as high strength waste with easily degradable suspended material⁵⁰. It has been shown that organic loads up to 10-20 kg COD/m³/d can be applied when the concentration and nature of organic matter are favourable⁵². Accumulation of suspended biomass and waste suspended solids along with the inorganic material precipitated from the waste (CaCO₃, metal sulphide etc.) cause plugging which leads to short circuiting and dead zone formation. This limits the specific microbial loading capacity⁴³. AF is capable of handling hydraulic and organic shock loads due to less possibility of microbial wash-out. The system has the added advantage that it can be satisfactorily operated without skilled supervision. Full-scale AF systems have been reported for treating various types of industrial wastewaters⁵⁰. The system is rarely used for sewage treatment at large scale⁵².

3.3 Downflow Stationary Fixed Film Reactor (DSFF)

DSFF reactor is a variant of anaerobic filter, where the oriented surface is provided for biofilm development^{50,53}. This provides a free channel for gas release. This arrangement avoids the accumulation of both suspended microbes as well as nonactive suspended material in the reactor⁵⁰, thereby reducing the plugging, short circuiting and dead zone formation. Added advantage of this reactor configuration is the elimination of elaborate distribution system at the waste inlet as the gases escaping through the top of the reactor readily disperse the influent waste. The loading depends on the formation and stability of active biofilm on the surfaces provided. Architecture of packing is important so as to avoid the accu-

mulation of nonbiomass suspended solids. Suspended biomass and undigestible suspended solids of wastes are removed along with the effluent.

DSFF can be used for a variety of wastes⁵⁰. However, degradation of suspended solids in the wastes depend upon their chemical nature as well as hydraulic detention time. Loading rate is limited by the active biomass retained in the reactor. As with AF, the reactor can be operated by semiskilled personnel.

3.4 Anaerobic Fluidized and Expanded Bed Reactors (FB/EB)

In this reactor type, fine carrier particles are used for the microbial film development. These particles with their attached biofilm are fluidized by high upflow liquid velocities derived by a combination of the influent and recirculated effluents. When the resulting bed expansion is up to 30%, the reactor is named as EB, if it is more than 30%, it is named as FB reactor⁵⁴⁻⁵⁶. Reactor performance depends on the evenness of the upflow of the liquid and hence the liquid distribution is very critical. Advantages of FB reactor configuration are large surface area of the particles for biomass attachment, high retained biomass concentrations attached to dense particles which cannot be easily washed out, the initial dilution of the influent with treated effluent minimizing the organic shock loads and no plugging channeling or gas hold up⁵⁶. The reactor configuration is suitable for the treatment of soluble organics or suspended material which could be easily degraded.

Typical disadvantages of FB/EB reactors are high energy demand for fluidization and high investment cost for liquid distribution to obtain uniform fluidization especially in a large scale plant. Operation and maintenance of the reactors require skilled personnel. So far, only a few pilot and bench scale studies are reported using FB/EB reactors.

3.5 Upflow Anaerobic Sludge Blanket (UASB) Reactor

The process relies on the tendency of anaerobic bacteria to form flocs or granules that are retained in the reactor by an efficient gas/liquid/solid separator device (GLSS) located at the top of the reactor. This reactor configuration was first developed by Lettinga and coworkers⁵⁷. The nature of the microbial aggregate, i.e. flocculent or granular, depends on the waste characteristics and organic loading⁵⁸. Although UASB systems can be operated with flocculent

sludge, granular sludge are preferable because of ease of separation as they have a high settling velocity. Thus extensive studies on the mechanism of granule formation, their structure and stability are being carried out. Granule formation is generally thought to be the result of environmental pressures and/or selection. Generally carbohydrate rich wastewaters lead to the formation of granules with excellent settling properties⁵⁹. Other mechanisms which have been suggested as being associated with granule formation are the importance of extracellular polymers produced by the bacteria^{60,61} and a requirement for inorganic nuclei⁶². It has been suggested that the filamentous bacterium *Methanothrix* plays an important role in bonding the granule components together³⁵⁻³⁷. Studies on the granule ultra structure suggest that it depends on the type of carbonaceous substrate. Carbohydrate degrading granules have a three layered structure³⁵, whereas more uniform structure was observed in granules degrading non-carbohydrate substrates^{36,37}. It is proposed that diffusion and rate of degradation of the substrate play a role in determining the ultrastructure³⁵.

Dominating advantages of UASB systems are the simple reactor construction, retaining high biomass concentrations thus allowing the process to achieve high removal efficiencies at high volumetric organic loading rates, low energy demand and extensive literature on application at laboratory, pilot and full-scale levels for various industrial as well as domestic wastewaters⁵⁸.

Limitations of the process are based on the development of granular sludge itself, which is still not completely understood. The system is sensitive to hydraulic shock loads. The presence of high concentrations of Ca^{+2} can lead to the accumulation of inorganic material in the reactor and ammonium ion, if present in wastewater, inhibits granulation. For efficient start-up and operation of the process, skilled supervision is necessary.

3.6 Hybrid Reactors

During the last decade many hybrid reactors have been developed which are combinations of above basic types⁶³⁻⁶⁶. They are mainly designed to overcome the limitations of UASB configuration. In an upflow blanket filter, filter type of packing media is provided at the top of the settler section of UASB to prevent suspended solids from escaping with the

effluent^{62,63}. A hybrid reactor in which filter media serves as the sole solid-liquid-gas separation device has also been developed⁶³. A hybrid reactor configuration using the concept of tube settlers to replace the conventional settler and GLSS device of UASB has been developed at the authors laboratory⁶⁵.

Another interesting example of hybrid reactor is anaerobic baffled reactor, which is a combination of UASB in series⁶⁶. This design offers high efficiency and good resistance to shock loading. Drawbacks of the design are a relatively complex reactor configuration and difficulty in evenly distributing the liquid. Most of these reactors are in the developmental stage and studies are mostly restricted to laboratory. Full-scale plant experience is still lacking.

A comparison of different reactor configurations discussed above show that each of them have some unique advantages and limitations (Table 2). Even though, EB/FB system shows the most favourable process behaviour, its application in practice is scarce. AF and UASB are extensively used in field for industrial wastewaters, whereas UASB seems to be the preferred reactor configuration for domestic wastewater treatment, in spite of its many limitations⁵⁸. In past 20 y, over 150 UASB units have been constructed around the world for treating high BOD industrial wastewaters like distilleries, sugar, milk, etc.

This demonstrates that investment and operation cost as well as the experience with full scale units are obviously much more important for application of technology for industrial and domestic wastewaters than some of the features which improve performance and process stability but lead to higher cost and complex reactor control.

In India, high rate anaerobic bioreactors especially AF and UASB are now extensively used for industrial wastewater treatment. Joshi *et al.*⁶⁷ have reported anaerobic treatment of domestic wastewater at the pilot plant scale. Recently the use of UASB for treating dilute domestic wastewater is contemplated. The world's first full-scale demonstration plant for municipal wastewater was built in Kanpur in 1985 under the Indo-Dutch Project and has been in successful operation since then. Encouraged by the result, a 14 MLD UASB plant at Mirzapur was constructed to treat the domestic sewage. Yet another plant of 36 MLD UASB treating combined

Table 2 — Salient features of different high rate reactors

Parameter	Type of reactor		
	UASB	AF	FB
Retained biomass concentration (VSS, g/L)	30-50	5-20	10-40
% suspended solids	100	20-80	0-10
Organic loading rate (kg COD/m ³ /d)	4-12	8-15	10-60
COD removal efficiency	80-95	60-90	70-93
Tolerates hydraulic shocks	(+)	+	+
Robustness against organic shocks	+	+	+
Sensitivity to clogging	o	+	o
Risk of biomass floatation	+	o	o

Note : o - No/None ; (+) - partial; (+) - Yes

domestic and tannery wastewater is operating in Kanpur since 1995^{5,6,68}. A 50 MLD UASB treatment plant is being constructed for Hyderabad city sewage, as a part of its master planning for Hyderabad with World Bank funding⁶⁹. UASB can be said to be the least demanding process on resources, in terms of energy and finances. The simplicity of the plant with almost total lack of equipment and benefit from power saving has made UASB to be the obvious choice of wastewater treatment in the developing countries.

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Scientific Community and Peer Review System —A Case Study of A Central Government Funding Scheme in India

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An attempt has been made to evaluate soundness of a peer review system operating for the funding scheme. An assessment of soundness has been made on the basis of fairness, rationality, responsiveness, and accountability. According to perception of scientists and engineers, the peer review system of the funding scheme appears to be fair, rational, accountable, and responsive. However, there appears to be an urgent need for improving the existing peer review system so as to maintain the image associated with scheme in future.

Introduction

Peer review system has been described as a mirror of science. To understand the working of a peer review system is to understand the *working of science itself*.^{1,2} With the institutionalization of scientific research in the seventeenth century, the concept of peer evaluation was invoked by the scientific community as a quality control mechanism. In fact, peer review is tightly woven in scientific community. It is a term referring to procedures which allow for advice from scientific community to funding agencies on the scientific merits of the proposed projects. Research proposals evaluation plays significant role in the governing process of scientific research. In olden days when budget for science was expanding, new opportunities could be availed without cutting funds for the existing research programmes. However, this does not hold good today, As decision makers ask for tight scrutiny of the effectiveness of research programmes. Thus, peer review system plays a crucial role in R&D programme evaluation.

As evident from published literature, peer review is generally used for evaluation of R&D programme and practically nil literature is available on results of an industrial evaluation research programme. However, the techniques and procedures used for evaluation of technological alternatives as regards industrial context are common. In other words, one

may gather an impression that industrial managers do not evaluate their research programme. But this is not so. A detailed evaluation of R&D programmes at IBM, and Community Energy Conservation and Solar Energy R&D programmes is discussed by Cozens. In fact, at NSF, Mc Elory had borrowed the programme review mechanism from NASA where it has been used as ongoing management tool to keep NASA's major projects. Similarly, techniques used in basic research were transferred to evaluate technology. For example, techniques used in Basic Energy Science Programme were applied to several programmes in Department of Energy and the Office of Naval Research.³ Many studies have been undertaken to evaluate the working of a peer review system, as it operates in the National Science Foundation and National Institute of Health in the US, for validation of their system. However, not a single study has been supported to compare such a system with other systems of allotting funds.⁴

Soundness of a peer review system has been evaluated on the basis of fairness, openness, and accountability. However, critics have expressed their concern for the unsoundness of the peer review system. Possibilities of peers operating as actors of old boys' club have been indicated. Some of the criticisms raised against peer review systems are : (i) It is felt that they favour their own people having simi-

lar cognitive and institutional particularism,⁵ (ii) It is alleged that the peer review system favours scientists working in prestigious institutions and it overlooks scientists working in less prestigious institutions,^{6,7} (iii) While awarding grants, peer review system is mainly guided by the prolific scientists, while new entrants are not encouraged, (iv) Funding agencies seem to play an excessive or improper role in selection of research projects in terms of decision-making pertaining to the number of peers and peers having insufficient knowledge of field to which the proposal belongs.⁸ Further, entrusting the right of allocation funds to a few individuals also contributes to a feeling of unfairness and suspicious of patronage,⁹ (v) Peers, sometimes, show regional bias and hence prefer scientists working in particular regions, (vi) It is believed that peer review system is not equitable, (vii) It is dominated by men and women who have very little say in this,¹⁰ (viii) It is also felt that review by peers disregards the multiplicity of system of assessment and the possibility of combining their best features. It involves enormous waste of resource and time of scientists which is inherently unfavourable to innovation. The schedule inherent in the process, often requiring some months to write elaborate proposals and a waiting period of 6 to 12 months does not correspond to actual schedule, according to which scientist works. In fact, this method/process encourages competition instead of co-operation and collaboration as the most effective mode of achieving the best scientific results.¹¹

In spite of all these criticisms, the scientific community feels that peer review is "still essential" to provide quality control.¹² In order to overcome these drawbacks and strengthen peer review system, Italy has redesigned its peer review system for health research, consequently the peer review system has been widened as each application seeking funds is being reviewed by six Italian experts and two foreign experts. After getting reviewed from referees ensuring honesty and high standards, those responsible for funding are not afraid of providing big sums.¹³ A panel comprising university scientists and NIH officials has been set up to monitor the ways in which peer review is applied to NIH grant application.¹⁴ In the same vein, a study was conducted to correlate the perception of peers regarding originality of research proposals and citation rates of researchers.¹⁵

Funding Scheme

For the first time in India, an attempt has been made to make appraisal of peer review system. Before going into details of the study, it is essential to describe working of the scheme. As regards the mechanism of peer review system operating for the scheme, the research proposals are received by the Department are scrutinised by the scheme secretariat in an internal meeting. During the meeting it is decided in which Programmes Advisory Committee (PAC) the proposal is to be processed. Research proposals are then sent to three/five referees by the PAC secretariat for evaluation. After the receipt of comments from referees, the principal investigators are invited to present their proposals before the members of PAC of different fields and the Department officials. The proposals along with referees and PAC members' comments are placed before the Council for final decision. The recipients of grant are informed about the amount allotted.

It appears that peer review system does exist in India but it is ineffective. There exist many funding agencies and of these, Department of Science and Technology (DST) and the Department of Biotechnology (DBT) appear to have comparatively well-established peer review mechanism.¹⁶ Other agencies like Defence Research Development Organisation (DRDO), the Department of Atomic Energy, the Indian Council of Medical Research (ICMR) and the Indian Council of Agricultural Research (ICAR) do not have so rigorous system. The scheme under study has a broad based peer review system but the problem still exists. It has been alleged that the scheme has been favouring a few personalities of southern region. In addition, it has also a bias for a few institutions. This may be either due to their background or the conflict of interest and ethics as reviewers and reviewees are receiving the grant from the same source.^{17,18} The soundness of a peer review system has been assessed on the basis of the following queries:

- (a) Whether peer review system is fair ?,
- (b) Whether peer review system is rational ?,
- (c) Whether peer review system is accountable ?,
and
- (d) Whether peer review system is responsive ?,

In the overall assessment, the efficiency and effectiveness of a peer review system has also been taken into account.

Methodology Adopted

Precoded and structured questionnaires seeking demographic and perceptual information were designed. The questionnaires were formulated for two categories of respondents:

- (i) Scientists and engineers who have applied for grant under the scheme.
- (ii) Scientists and engineers who have not applied for grant under the scheme.

The questionnaires were pretested in some research laboratories/institutions within Delhi (Indian Agricultural Research Institute (IARI), Delhi University (DU), National Physical Laboratory (NPL), Central Road Research Institute (CRRI), and Indian Institute of Technology (IIT). The demographic information sought pertained to sex, type of institute, and field of specialization to which the respondents belong. Perceptual information was sought on the following aspects: Procedures followed for submission of proposals, evaluation mechanism used in the peer review system, and overall assessment of the scheme. Copies of the questionnaires were mailed to more than 1200 scientists and engineers, applicants and non-applicants for scheme during 1985-1990. About 750 completed questionnaires were received back. Thus, the response rate was more than 60%, which is a very good response rate for any survey.

As regards the reliability and validity of the variables, inter-item correlations among various variables, means and Cronbach alpha have been computed. The values of α show high levels of reliability. The value of α for each variable varies between 0.7 and 0.9. Cronbach has been computed using the following formula:

$\alpha = (K / K - 1) (1 - \sum \sigma^2_i / \sigma^2_t)$; where K = Number of items in the variable; σ^2_i = Variance of item i ; and σ^2_t = Variance of item t .

All the values of inter-item correlations are found to be statistically significant and large, indicating convergent validity.

Scrutiny of the theoretical framework of a peer review system reveals that a sound peer review system should act as a flywheel. On the one hand, it should be able to defend the autonomy granted to the

scientific community, and on the other hand, it should make science accountable to society. In addition, it should be able to certify the soundness of new developments in science and technology (S&T). Within this framework, the following aspects were taken into consideration for evaluating the peer review system for the concerned funding scheme:

- Fairness.
- Rationality.
- Responsiveness.
- Accountability.

Profile of Respondents

Field of Specialization

A majority of the respondents belong to life sciences (41.5%), followed by physical sciences (19.5%), chemical sciences (17.7%), and earth and atmospheric sciences (5.5%) (Fig.1). In fact, the pattern of respondents specialization corresponds to the pattern of financial support given in different fields under the scheme during the period under study. As expected, a majority of the respondents are males (91%) and the rest are females (9%) (Fig.1).

Nature of Research

Large majority of the respondents are engaged in basic research (49.0%) followed by applied research (40.0%), and experimental research (about 11%). Most of the respondents engaged in basic and applied

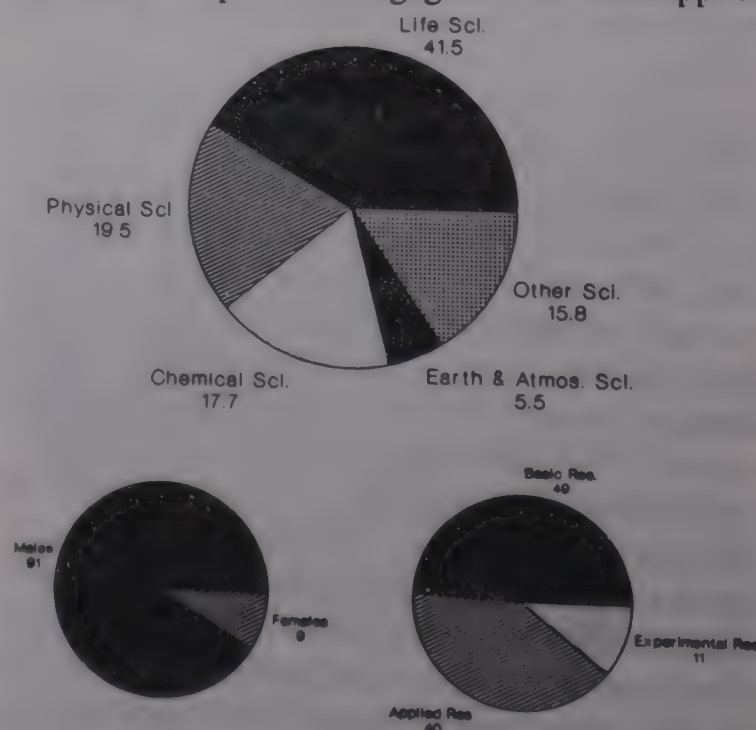


Fig. 1 — Sample characteristic

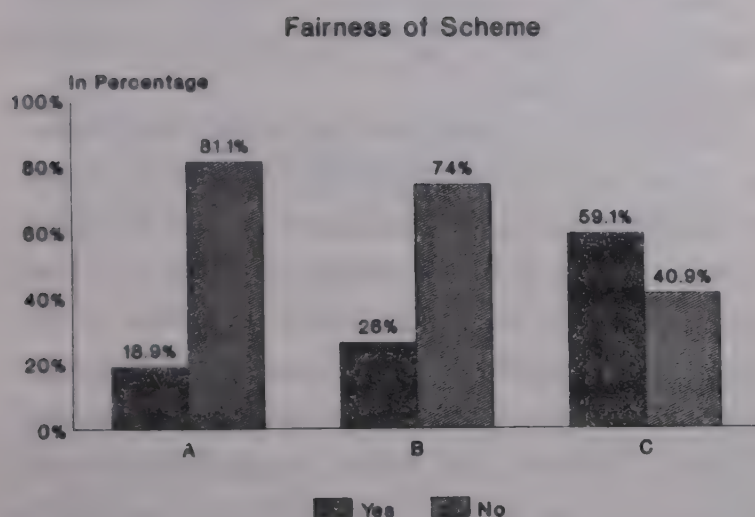


Fig. 2 — (A) = Grant depends on chance; (B) =Regional bias within scheme, (C) =Decision are consistent with comments of reviewers/referees
research belong to the age groups 36-45 y, 46-45 y, and more than 55y.(Fig.2).

Results and Global Level Analysis

(a) Fairness of the Scheme

The study attempts at answering a few queries. How fair is the functioning of the scheme? The scheme has been evaluated depending on the following sources :

- Fairness of the Scheme,
- Fairness of a Peer Review System, and
- Fairness of a Peer Review Procedure.

For judging fairness in functioning of the scheme, respondents were asked to indicate their perceptions on the following variables :

- The scheme grant depends on chance,
- There is regional bias in the scheme, and
- Decisions made by the funding Department are consistent with peers/reviewers' comments.

A majority of the respondents disagree that getting a grant depends on chance. About 74% of the respondents perceive there is no regional bias. Only 59% of the respondents agree that final decisions made by the funding Department are consistent with comments of the reviewers and referees. Therefore, one

can conclude that the functioning of the scheme is fair (Fig.2).

(b) Fairness of Peer Review System

For measuring the fairness of the peer review system, the respondents were asked to indicate their perceptions on the following points:

- Comments of reviewers carry equal weight,
- Reviewers dominate in the peer review system, and
- PAC members have equal say.

A few of respondents (28.8%) agree that reviewers' comments carry equal weight and a majority (58.5%) of the respondents agree that reviewers dominate in the decision-making process in the peer review system and only one in three respondents agree that PAC members have equal say in decision making (Fig 3).

(c) Fairness of Review Process

Fairness of peer review procedures has been assessed on the basis of influence of chance and casualness, and external influence on the review process for funding.

Regarding fairness of a peer review procedures, a majority of the respondents disagree that chance, casualness and extraneous influences affect the funding decision under the scheme (Fig 4).

In this context comments made by respondents are summarized below.

It is suggested that PAC should have the comments of the subject referees evaluated. In addition, the proposals should not be accepted or rejected on the basis of the referees' comments alone. The prin-

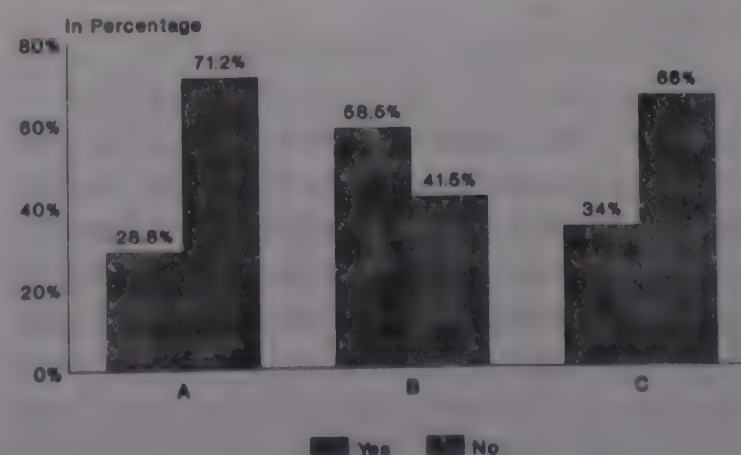


Fig. 3 — (A) = Reviewer's comments carry equal weight; (B) =Some reviewers dominate the decision; (C) =PAC member has equal say in decision making

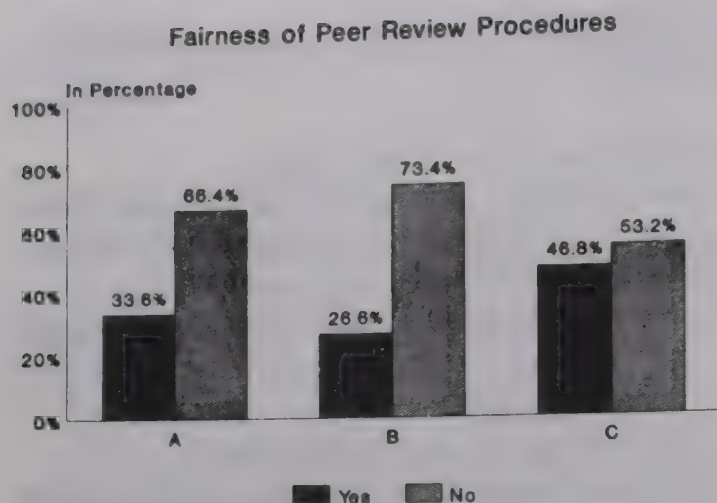


Fig. 4 — In peer review process for funding whether there is (A) =Chance; (B) =Casualness; (C) =Extraneous influences

cipal investigators (PIs) should be given a chance to make a presentation before a group of experts or PAC members. According to another suggestion, frequent convening of PAC meetings should be avoided. This entails saving of lot of money.

It has been argued that PAC meetings do not serve any useful purpose, because it is not possible to explain a project in a few minutes' presentation. In case any PAC member/expert has any query, it should be referred to the concerned scientists by mail through the Department. It is observed that many PAC members do not read the project proposals seriously and do not give comments in a serious frame of mind. It is suggested that PACs should restrict themselves to the job of discussing the major points in the peer review without going into financial and administrative issues. A few respondents have opined that most of the projects are considered on the basis of personalities rather than the merits of the project contents.

One of the weaknesses of the PAC system which can be pointed out is that most of the members are unaware of the present status of the concerned field. PAC should seek a personal interview with the principal investigator before recommending acceptance or rejection of the proposal. In the event of rejection, the reasons for this should be stated clearly. It is felt that if PAC members do not have sufficient scientific expertise relating to the proposal, then only should the proposal be sent for evaluation to referees. There is a need for a drastic change in the attitude of PAC members, so that instead of playing the role of seniors/examiners they act as academic advisors with the aim of effecting improvements in project proposals.

Regarding the quorum, the respondents feel that at least two-third of members of PAC should be present at a meeting in which decisions are taken. It is also felt that when PAC members do not have requisite expertise in the field, additional experts should be inducted.

It is felt that to incorporate an element of objectivity, a system of ranking/grading research proposals by the PAC should be introduced and the applicant scientists should be intimated about it. Ranking should be done on the basis of relevance of the project, its scientific content, planning and presentation capabilities of the investigator, infrastructural facilities available, and future prospects in the context of national needs. The Advisory Committee should include experts having good R&D records.

In the opinion of some respondents, no system can be efficient if people who man it are parochial in their outlook. From people with mediocre abilities acting as peers/PAC experts, great achievements cannot be expected. The term of PAC members should be reduced from 3 to 2 y. Only 50% of members should be given a second term and none beyond that. The age of members should be 40-50 y and in no case it should exceed 60 y. More and more young and active members should be inducted into PAC rather than retired and superannuated persons. No reviewer should be a member of more than one committee.

It is suggested that a stratified time schedule should be worked out and adhered to in the processing of proposals. Comments on proposals should be intimated to PIs. A list of proposals accepted/rejected should be prepared incorporating detailed comments for and against, with the names of referees. PIs should discuss their proposals with reviewers through correspondence before decisions are taken about acceptance/rejection of their proposals. Revised proposals on the basis of comments should be sought. A well-written proposal should not be the only criterion for evaluation. It is also opined that personal favours on the part of the Department officials should be eliminated. It is suggested that the concerned officer should be deputed by rotation. This would eliminate the chances of their building up links with reviewers and peers.

Rationality of SERC Peer Review System

The respondents were asked to indicate the order of importance of a set of criteria for acceptance or rejection of the proposals. These criteria are as follows:

- (i) Scientific content of the proposal;
- (ii) Capability of the principal investigator;
- (iii) Institution's ability to provide infrastructural support for the work;
- (iv) Scientific weakness of the conception of the research proposal; (v) Scientific incompetence of the principal investigator;
- (vi) Contribution to identified frontline areas;
- (vii) Presentation of the proposal before the committee, and
- (viii) Unpleasant experience of the funding agency about the principal investigator.

The respondents were asked to indicate the order of importance of a set of criteria for acceptance or rejection of proposals.

Criteria for Acceptance of Proposals — Two types of criteria are used for this. Subset I comprises scientific value of proposal and scientific performance of the principal investigator. These are the criteria which are mainly used for evaluation of proposals under the scheme. Subset II of criteria consists of contribution to identified frontline areas by the funding Department, methodological adequacy, presentation of proposal before the committee which evaluates the proposals.

Most of the respondents have given importance to all the criteria listed above. It may be mentioned here that the highest importance has been given to the scientific value of the proposal, while least importance has been given to the institution's ability to provide infrastructural support (Fig. 5).

It is suggested that a quantitative assessment should be obtained from each reviewer on 1 to 10 scale with regard to the following criteria:

- (i) Originality in concept;
- (ii) Clarity of hypothesis/proposal;
- (iii) Importance of the project to the concerned field;
- (iv) Expertise available in the institute;
- (v) Adequacy of methodology proposed;

Criteria for Acceptance of Proposals

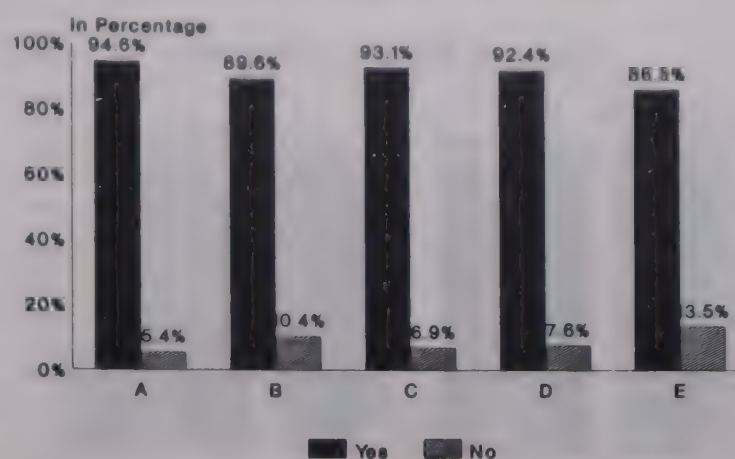


Fig. 5 — (A) =Scientific value of the proposal; (B) =Past performance of principal investigator; (C) =Contribution to identified frontline areas; (D) =Methodological adequacy; (E) =Presentation of the proposal before committee; (F) =Institution's ability to provide infra-support

- (vi) Relevance of the project to national needs;
- (vii) Applicability of results;
- (viii) Provision for training of personnel;
- (ix) Costs or prices vis-a-vis importance of scientific objectives, and
- (x) Probability of successful completion of the project at the institution.

Criteria for Rejection of Proposals — Like approval criteria, rejection criteria also comprise two subsets. Subset I includes scientific weakness of the conception of the research proposal and scientific incompetence of the principal investigator. These are the main criteria on the basis of which project proposals are rejected. Included in Subset II are criteria that the proposal duplicates someone else's proposal, research proposal beyond priority themes, unpleasant funding experience of the Department with the concerned Institute and the subject falls within the purview of other agencies like ICMR and DRDO.

An overwhelming majority of the respondents (93%) have given maximum importance to scientific weakness of the conception of research proposals. Next in order is the criterion that the proposal duplicates someone else's proposal (90%). The least importance has been given to the criterion that the subject falls within the purview of other agencies like ICMR and DRDO (Fig 6).

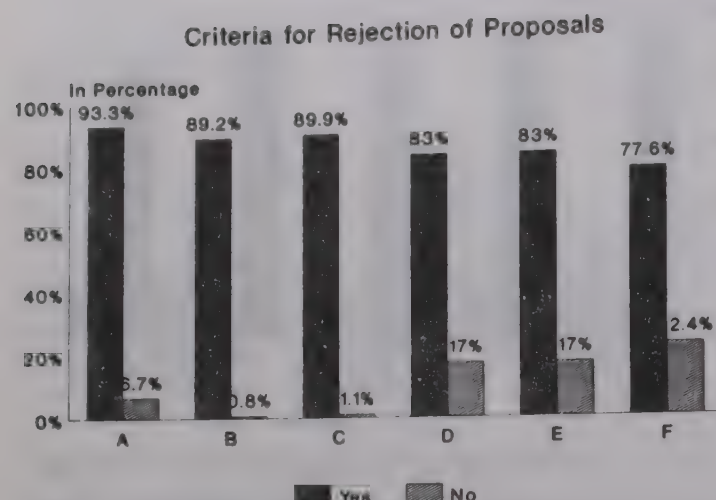


Fig. 6 — (A) =Scientific weakness of the conception of the research proposal; (B) =Sci incompetence of the principal investigator; (C) =Proposal duplicates someone other's proposal; (D) =Research proposal beyond priority themes; (E) =Sufficient funds already exists within the institution; (F) =Previous unpleasant funding exp. of Scheme by the institution

Accountability of Peer Review System

The respondents were asked to give their views regarding the following statements :

- (i) Department keeps in view activities of the agencies in decision-making;
- (ii) Peer review of the scheme improves the quality of scientific research;
- (iii) Satisfaction of respondents' regarding the review process, money allocated and S&T personnel

Though a large majority of the respondents appear to be satisfied with the review process, money allocated, S&T personnel and the laboratory involved, the respondents are relatively more satisfied with review and S&T personnel comparison to money allocated and laboratory equipment.

Most of the respondents (71.5%) feel that Department keeps in view the activities of other funding agencies in decision-making process. However, only 63% of the respondents opine that review mechanism ensures quality of scientific research in the country (Fig. 7).

Responsiveness of Peer Review System

For evaluating the responsiveness of the peer review system, the respondents were asked to give their perceptions on the following statements :

Peer review system operating within the Scheme is too cumbersome and deters many researchers from even preparing a proposal.

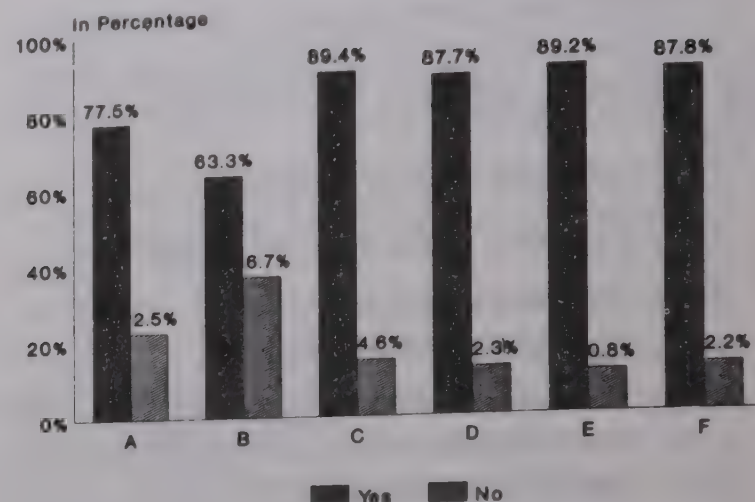


Fig. 7 — (A) =Activities of other funding agencies; (B) =Scheme mechanism improves quality of sci research; (C) =Review process; (D) =Money allocated; (E) =S&T personnel; (F) =Laboratory equipment

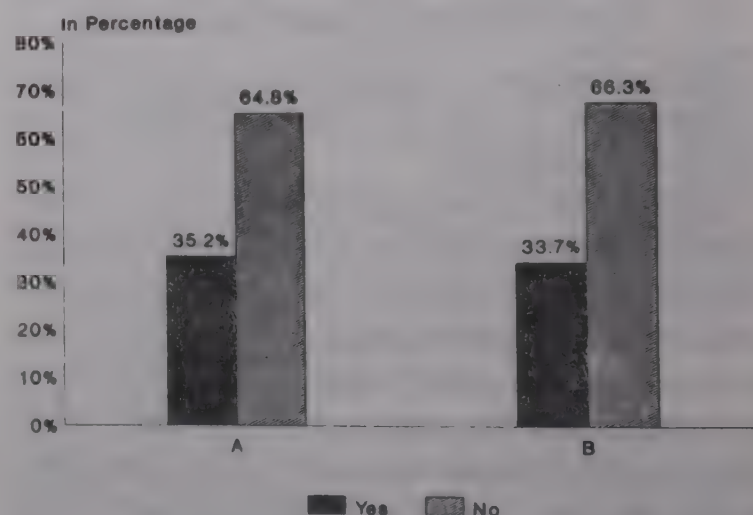


Fig. 8 — (A) =Scheme peer review system is too cumbersome; (B) =Creative scientific ideas rejected

Creative ideas challenging or questioning the existing approaches are often rejected by the reviewers.

Most of the respondents are in disagreement with these two statements. However, the proportion of those in disagreement varies between 64.8% and 66.3% for various measures (Fig 8).

Effectiveness of Peer Review System

For this, perceptions of the respondents were sought on the following statements:

- Review process within the scheme ensures high standard of excellence in project selection.
- Research proposals should be reviewed by foreign experts.
- Peer review mechanism improves the quality of scientific research in the country.

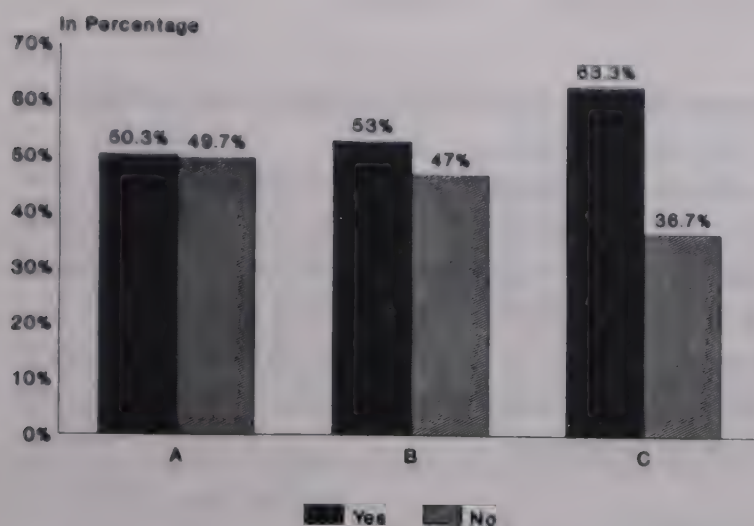


Fig. 9 — (A) =Ensures high standards of excellence; (B) =Reviewed by foreign experts; (C) =Scheme mechanism improves quality of scientific research

Most of the respondents disagree that peer review mechanism improves the quality of scientific research in the country. The perceptions of the respondents are more or less equally divided on issues such as: review process ensures high standard of excellence in project selection and review of the proposals should be done by foreign experts (Fig. 9).

It has been suggested by the respondents that a team of three impartial and unbiased referees should be involved in peer review. More than one referee should be involved, especially if one referee rejects the proposal. Peer review should not be confidential. Feedback from the reviewers to scientists in the form of comments is an essential element. When most of the referees give a positive recommendation, the proposer should be allowed to present his proposal to the PAC in person.

Another recommendation is that confidential review by three or four experts should be sought. In case all the referees are unanimous in recommending the project, it should be awarded straightaway. If the reports are of mixed nature, meeting/discussion involving the reviewers and the investigator may be arranged in order to have a meaningful dialogue with the principal investigator. In emerging areas, foreign experts may be requested to review proposals.

It is opined that a member from the concerned PAC should visit the laboratory for constant review of the progress of the project. If more than one member are required to visit the laboratory, they should do so independently and written reports in a standard format should be made available to the PAC. All the PAC members must submit their critical appraisals within three weeks of receipt of docu-

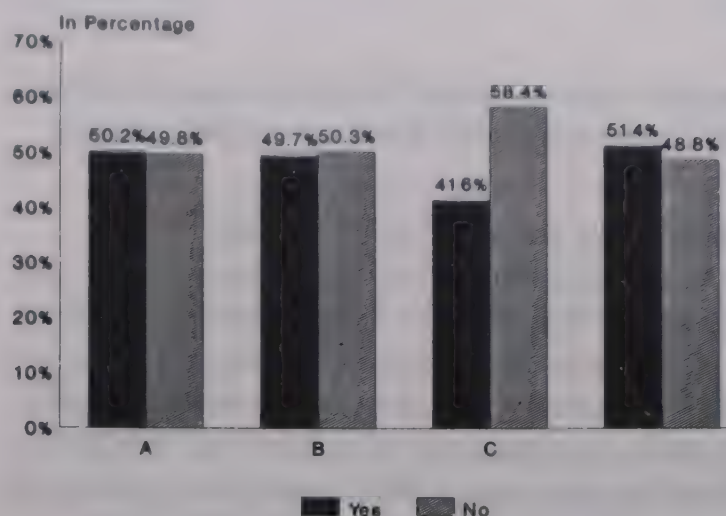


Fig. 10 — (A) =Devote sufficient time; (B) =Do careful reading of proposals; (C) =Give valuable comments on subject/methodology; (D) =Is PAC mechanism appropriate for evaluation?

ments from Department. Deliberations at PAC meetings should be conducted seriously with adequate attendance of members. It is suggested that there is a room for improvement in the system being currently followed for constitution of PACs.

It is suggested that proposals should be examined by competent field experts and not in bulk by PAC, which should concern itself primarily with progress evaluation.

Efficiency of Peer Review System

The efficiency of the peer review system has been evaluated on the basis of the following criteria :

- While evaluating the research proposals, peers devote sufficient time, do careful reading of the proposals and give valuable comments about the subject matter, methodology, etc.
- Programme Advisory Committee (PAC) is an appropriate mechanism for evaluation

About 58% of the respondents are in disagreement with the statement that the peers while evaluating the project proposals give valuable comments about the subject matter, methodology, and implications. However, the opinion of the respondents is more or less equally divided on peers devoting sufficient time, peers doing careful reading, and appropriateness of PAC mechanism for evaluation (Fig. 10).

The present peer review system can be improved by strictly adhering to the quality aspects of the project proposal and making the investigators more accountable for the funds provided to them while

sanctioning the projects. The system should be based strictly on merit rather than on personality culture.

Conclusions and Recommendations

According to the perceptions of respondents, the peer review system of the funding scheme appears to be fair, rational, accountable and responsive. However, they have expressed an urgent need for improving the existing peer review system so as to maintain the image associated with scheme in future. For this, the following measures, can be suggested.

Improving the Peer Review System

Though the functioning of the scheme and the review procedures appear to be fair on the basis of the responses, some doubts have been expressed regarding the peer review system. In this context, one should avoid a situation under which a peer fails to offer critical comments. In fact, peer review system should act as a flywheel and should be able to preserve the autonomy of the scientific community and make science accountable to the society.

It is suggested that the peer review system should be strengthened by adding new/young experts on the panels prepared for different disciplines. Experiences from the advanced countries highlight that peer review system should be open and should never be confidential and secret. In the open peer review system, both peers and proposal submitters should sign the comments and proposals, respectively. The comments should be sent to the project proposers and the latter should be able to send their rejoinders. Managers should make their judgement on the basis of peers' comments and proposers' rejoinders and finally select projects for the award of grants. Moreover, it is only in the open peer review system that the proposer and reviewer can learn from each other, which is essential for nurturing quality scientific research. It is further suggested that comments of a minimum of three peers should be taken into consideration while taking decisions on each proposal, irrespective of the status of the applicant and his/her institutional affiliation.

Upgradation of Peer Review System

Decisions regarding the funding of various projects should not be made merely on the basis of peer ratings of projects. Bibliometric indicators and pro-

posers' history should also be given equal weightage in decision-making.

Peers are generally busy in their research activities, and reviewing work should not be sandwiched between these research activities. Rather peers should be rewarded for honest and sincere jobs, and there would be no harm in blacklisting dishonest peers, or those who display a casual attitude in reviewing proposals.

Procedural Changes

There is a need to simplify the project proforma so that it can serve the purpose of evaluation more effectively. It appears that Department is asking for 30 copies of the proposals for completing the review process. As a matter of economy, it is advisable to reduce the number of copies to ten. In some cases, the review process has taken about 12-18 months. Respondents feel that this time period should be reduced to six months.

It appears that the chairmen and members of PAC have been given unlimited powers to manage the funding of the research projects. It is suggested that all the projects which have been reviewed by the peers need not go to PAC. The projects which have received consistently positive ratings should be funded directly and referred to PAC later on. Only projects with doubtful ratings should be presented before PAC. The time allotted for making presentation before PAC should be strictly adhered to in view of the complaints that generally presentations made in the beginning of a meeting of PAC are given more patient hearing than presentations made towards the end.

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Wild Banana Plants (*Musa Spp*) as Source of Fibre for Paper and Cordage Industries

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Paper making grade pulp was prepared from three varieties of wild banana plant, viz. *Musa velutina* Wendl & Drude, *Musa sanguinea* Hook and *Musa manii* Wendl ex Baker, which were collected from high altitude regions of Assam and Arunachal Pradesh. Also, fibres were extracted for making ropes and twines from these banana plants. The physical characteristics of the banana plants were evaluated and proximate chemical analyses were carried out. The plants contain on an average, 25-27 % sheath, 42-48 % central core and 27-30 % leaves. The cellulose contents in the plants varied from 60.2-62.5 %. The unbleached and bleached pulp yields were 42.9-45.0 % and 38.7-40.2 % respectively for all the three varieties. Paper hand sheets formed from bleached pulp (45°SR) exhibited physical strength properties of burst indices (4.5 - 5.0 K Pam²g⁻¹), tear indices (9.32 - 10.20 mN m²g⁻¹) and tensile indices (53.3-60.8 Nmg⁻¹), indicating high strength properties for writing and printing paper, while paper sheets prepared from pulp beaten to 90°SR showed good greaseproof properties. Three ply twines made from banana fibre (2.86 mm diameter) and jute fibre (3.0 mm diameter) gave breaking loads 179.32 N and 176.70 N respectively. From this study, it may be concluded that the banana plants would be good source of raw material for cordage industry and a supplementary source for pulp and paper industry.

1. Introduction

Banana is one of the important fruit and vegetable crop plants and belongs to the genus *Musa*. It not only grows wild, but is cultivated on a large scale as a field crop as well as a backyard crop in households. Banana plants are available over wide areas throughout the tropics from 30°N to 30°S of equator. India, being a tropical country, banana is cultivated in about 1,86,000 hectares of land¹. In India, the most satisfactory conditions for cultivation are found along the coastal regions of Kerala, Tamil Nadu, Maharashtra, West Bengal and Assam. In all these areas and to a certain extent in the hill slopes of South India and in Assam upto an elevation of 800 m, banana is grown as rain fed crop. In other parts of India, it is grown under irrigation, particularly during December to March. A well distributed rainfall of 175-250 cm per annum is ideal for its cultivation though it is able to stand heavy rainfall of 380 cm or more per annum. The plant has luxuriant growth in rich well drained

soil with ample moisture and decaying organic matter. It can also flourish on light sandy or gravelly soil as well as on stiff but well drained clay, if the soil is fertile and facilities for irrigation are available².

From the pseudo stem portion of the plants, crude fibres are extracted on small scale and utilized for making ropes and twines. The tradition of extraction and usage of banana fibre is wide spread in the Pacific region, e.g. New Guinea, Japan, the Solomon Island, China and Philippines. The quality of fibre varies not only with the stage of maturity of the plant during fibre extraction and the position of the corresponding sheath in the stock but also with the species³. Recently, studies have been made for evaluation of yield, structure and properties of banana fibres extracted from a few cultivated varieties¹. The harvested stalks of the plant are utilized for extraction of fibres. The fibre is located primarily adjacent to the outer surface of the leaf sheath. It was reported that well cleaned and brushed decorticated

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whole leaf sheath pulp may yield 80-85% long (4-6 mm), slender (mean width 17-21 μ m) fibres⁴.

With the growing shortage of cellulosic fibres, search for alternative fibre producing plant material has been initiated in many countries throughout the world. The generation of alternative fast growing plant is thought to be one of the solutions to this shortage of fibres⁵⁻¹¹. The banana fibres may serve partly as an alternative for conventional paper making fibres. Moreover, it can also be used in cordage industries. Studies on physicochemical compositions and extraction of fibres from some Philippine banana and from *abaca* (*Musa textilis*) were taken up with encouraging results¹². Also studies on pulping and paper making from banana (*Musa cavendish*) plants were also carried out^{13,14}.

Laboratory scale investigation was carried out to find out the suitability of a few varieties of wild banana plant grown in regions of high altitude in the states of Assam and Arunachal Pradesh, firstly for use in preparation of pulp suitable for paper making and secondly for extraction of fibres for use in cordage industries for producing ropes and twines.

Table 1 — Physical characteristics of the banana plants

	<i>M. velutina</i>	<i>M. sanguinea</i>	<i>M. manii</i>
Stem length, cm	350	350	250
Stem diameter, cm	25	25	20
No of leaves	7	8	6
Length of the leaves, cm	165	175	175
No of sheath in stem	12	10	8
Diameter of the core, cm	10	12	8
Green weight of the stem, kg	28	26	24
Moisture content, %	92	89	89
Average constituents of the plant (% on O.D. basis)			
Sheath	27	28	25
Central core	45	42	48
Leaves	28	30	27

The results are average of 20 readings for each species.

2 Materials and Methods

The biomass used for the study reported here was collected from the hilly areas of Assam and Arunachal Pradesh. The following three species viz *Musa velutina* Wendl & Drude, *Musa sanguinea* Hook and *Musa manii* Wendl ex Baker were selected for evaluation. The physical characteristics of the plants are presented in Table 1.

The sheaths were separated from the plant, washed with cold water and cut into chips of 2.5-4 cm length and 4-5 cm width. The chemicals used are of commercial grade.

2.1 Proximate Analysis

The oven dried (O.D.) chips were powdered in a Wiley mill and the material was made to pass through 40 BS mesh and retained on 60 BS mesh. These powdered samples were analyzed for their different chemical constituents and solubilities as per TAPPI standard methods¹⁵ and the results are presented in Table 2.

2.2 Preparation of Pulp for Paper and Evaluation of Strength Properties

For the preparation of paper grade pulp, the sheaths were crushed in a two-roll crusher in order to reduce the moisture content and floating of the material during digestion. It also helped in penetration of cooking chemicals throughout the sheath uniformly. The cooking was done in pressure free condition by adopting Soda process where commercial grade sodium hydroxide (8%) was added on the

Table 2 — Proximate chemical analysis of Banana species

Particulars	<i>M. velutina</i>	<i>M. sanguinea</i>	<i>M. manii</i>
Solubilities, %			
Cold water	2.5	2.3	1.8
Hot water	2.8	3.0	2.5
1% NaOH	26.5	28.3	27.2
Alcohol benzene	2.5	1.80	2.0
Cellulose (Cross & Bevan), %	60.2	62.5	61.3
Lignin, %	16.0	17.5	18.7
Pentosan, %	17.2	18.5	17.8
Ash content, %	1.8	2.0	2.5
Alpha Cellulose, %	55.2	56.8	54.7
Silica, %	0.58	0.67	0.89

weight of O.D. chips at bath ratio 1:6 for a period of 2 h. The average yields of unbleached and bleached pulp, Kappa numbers of unbleached pulp, brightness and viscosity values of bleached pulp were measured as per TAPPI standard methods and the results are shown in Table 3. Bleaching of the pulps was done by adopting chlorination - alkali extraction and hypochlorite (C-E-H) treatment sequence and the brightness of pulp thus obtained was recorded. Hand sheets of $60 \pm 2 \text{ gm}^{-2}$ were prepared from both unbleached and bleached stock at 45°SR and evaluated for the physical strength properties which are

Table 3 — Pulp yields, Kappa numbers, Viscosities of unbleached and bleached pulps

	Properties					
	Pulp yield %		Kappa number	Pulp brightness %	CED* viscosities (Cp)	Initial pulp freeness (°SR)*
	Un-bleached	Bleached				
<i>M.velutina</i>	45	40.2	27	76	7.6	15
<i>M.sanguinea</i>	44	39.5	28	75	7.2	16
<i>M.manii</i>	42.9	38.7	26	76	7.4	18

*CED— Cupriethylene diamine, SR— Schopper Riegler

recorded in Table 4. Highly hydrated stock of banana pulp was also prepared by beating the pulp up to the freeness of 85°SR . Handsheets of $45 \pm 2 \text{ gm}^{-2}$ were prepared and evaluated for their strength as well as greaseproof properties and these results are also reported in Table 4. Morphological properties of pulp fibre such as fibre length, diameter, lumen width etc were determined and are recorded in Table 5.

2.3 Extraction of Fibres for Cordage Industry

The sheaths of banana plant were stripped to an average width of 4-5 cm and cut into length of 60 cm. The cut strips were made into bundles and tied at both ends with jute twines and fed into a cubical vessel of $60 \times 60 \times 45 \text{ cm}$ size. The bundles were placed horizontally and required quantity of water was added to maintain the bath ratio 1:6; 12.5% Sodium carbonate on the weight of OD material was added and cooking continued for 2 h at boiling temperature. After cooking, the bundles were washed in running water till the material was free from alkali. The washed material was dried in air by hanging on ropes. The dried fibres were treated for 24 h with an emulsion prepared from soap and mineral oil for softening. The softened fibres were then chopped to a length of 30 cm to facilitate feeding into carding machine in a conventional jute twine making unit. The fibres were then converted to slivers and finally three ply twines were made. Breaking loads of three ply twines made from banana fibre, jute fibre, and

Table 4 — Physical strength properties of writing and printing, and greaseproof paper sheets

	Sample	Pulp freeness	Beating time	Burst index	Tear index	Tensile index	Double fold	Oil trans-udation period (s)	Blister
		$^\circ\text{SR}$	min	$\text{Kpam}^2\text{g}^{-1}$	$\text{mNm}^2\text{g}^{-1}$	Nmg^{-1}			
<i>M. velutina</i>	A	45	15	4.5	9.32	58.65	250	—	—
	B	90	100	5.8	6.82	62.21	320	1800 ⁺	Very good
<i>M. sanguinea</i>	A	45	18	5.0	10.2	53.3	280	—	—
	B	90	120	6.2	8.6	68.0	340	1800 ⁺	Very good
<i>M. manii</i>	A	45	15	4.8	9.87	60.8	200	—	—
	B	90	100	5.2	7.10	64.2	280	1800 ⁺	Very good

⁺ indicates a value more than the figure

Table 5 — Morphological properties of pulp fibres

Properties	<i>M. velutina</i>	<i>M. sanguinea</i>	<i>M. manii</i>
Fibre length, (L) mm			
Maximum	6.28	5.75	6.00
Minimum	0.58	0.75	0.65
Average	1.35	1.28	1.20
Fibre width (D), μm			
Maximum	24.5	25.2	24.7
Minimum	12.8	13.7	14.5
Average	20.2	18.8	20.0
Lumen width (Average) (d), μm	12.5	13.7	14.2
Cell wall thickness (Average) (W), μm	5.8	6.2	5.6
Runkel ratio, (2 W/d)	0.93	0.91	0.79
Slenderness ratio, (L/D)	66.8	68.1	60.0

Table 6 — Comparative results of breaking load obtained from 3 ply twines

Properties	Banana fibre (100%)	Banana Jute (50:50)	Jute fibre (100%)
Weight (g per meter of linear 3 ply twines)	2.668	2.692	2.895
Diameter (mm)	2.86	2.82	3.00
Breaking load (N)	179.32	177.80	176.70

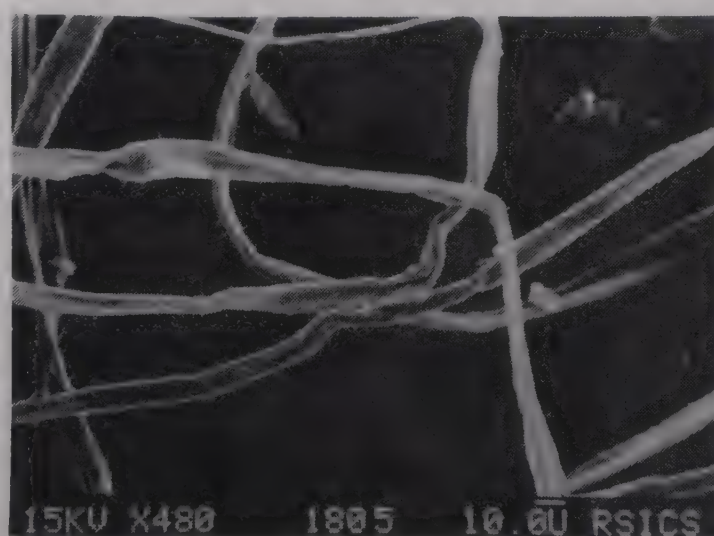


Fig. 1(a) — Photomicrograph of a banana pulp fibre

jute and banana fibre blends were found out and the results obtained are recorded in Table 6.

3 Results and Discussion

The length and diameter of stem, core and leaves of matured banana plants were measured by a graduated measuring tape. From Table 1, it can be seen that, when freshly cut, the plants contain 89-92% moisture. The average weight of plant including leaves on wet basis varies from 24-28 kg. The plants consist of about 27% sheaths, 45% central core and 28% leaves. Since, the leaves get dried quickly, the leaves are eliminated for pulping, but the midrib of the leaves is also included for pulping. The leaves without midrib constitute about 4% of the whole plant.

The proximate analysis of the plant materials shows 60.2 - 62.5% Cross and Bevan cellulose. Amongst the three varieties, *M. Sanguinea* shows higher cellulose content compared to *M. velutina* and *M. manii*. The alpha-cellulose content is comparatively high (56.8%) in *M. sanguinea*. Not much variation is found in lignin and pentosan contents in all

the three varieties. The ash content varies from 1.8-2.5%, while silica in ash is found at 0.58-0.89%. The solubility figures, especially alkali solubilities are high in all the varieties as compared to those of conventional raw materials.

The yield of pulp (both unbleached and bleached) obtained from *M. velutina* is higher in comparison to other two varieties (Table 3). The CEH sequence of bleaching seems to be suitable for banana pulp. About 6.8-7% total chlorine (5.5% in chlorination stage and 1.3-1.5% in hypo-stage) was required for unbleached pulp of Kappa number 26-28, to get a bleached pulp brightness of 75-76%. Table 5 shows that there is not much variation in fibre length and diameter. The lumen width and cell wall thicknesses of fibres of *M. velutina*, *M. Sanguinea* and *M. manii* vary within a narrow range. The average fibre length

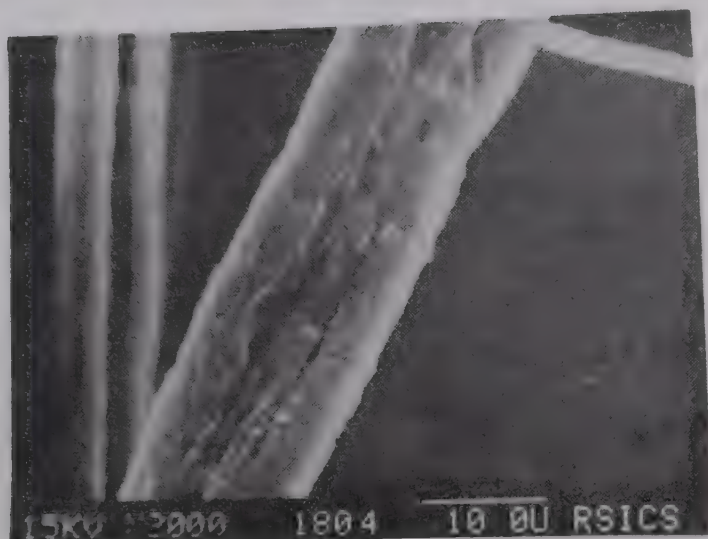


Fig. 2(a) — SEM of single banana pulp fibre

for all the three varieties is within 1.20-1.35 mm, while fibre width varies from 18.8-20.2 μm . The Runkel ratio for the fibres is less than 1. The morphological properties exhibit good physical strength of the pulp. Fig. 1(a) shows the banana pulp fibres which are flattened and thin walled with constrictions in some portions in the length of the fibre. Fig. 1(b) shows the scanning Electron Micrograph (SEM) of a single banana fibre, which exhibits longitudinal cracks on the surface of the fibre.

The strength properties of the pulp are found quite satisfactory for preparing writing and printing papers. Out of the three varieties, *M. Sanguinea* shows better strength properties of paper. The burst and tensile indices of paper sheets ($60 \pm 1 \text{ gm}^{-2}$) made from pulp of *M. Sanguinea* are $5 \text{ Kpam}^2\text{g}^{-1}$ and 63.3 Nmg^{-1} respectively, while that obtained from *M. velutina* and *M. manii* are $4.5 \text{ Kpam}^2\text{g}^{-1}$ and $4.8 \text{ Kpam}^2\text{g}^{-1}$, and 58.65 Nmg^{-1} and 60.8 Nmg^{-1} respectively. The highly hydrated stock of pulp (beaten up to $85\text{-}90^\circ\text{SR}$) shows grease-proofness properties in the pulp sheets of $45 \pm 2 \text{ gm}^{-2}$ (Table 4). The strength properties of three ply twines made out of banana fibres, jute and banana fibre blends, and jute fibre alone, show that the breaking load of twines made out of banana fibre is comparable to the other two¹⁶.

4 Conclusion

From the above study, it can be concluded that wild banana species viz *M. velutina*, *M. sanguinea* and *M. manii* can be utilized for making paper grade pulp. Greaseproof paper can also be made out of the pulp prepared from banana plant. The fibre can also be used in cordage industry for producing twines and ropes with adequate strength. As the fruit of these varieties of banana are not edible, these biowastes can very well be used for making paper grade pulp as well as for producing articles of day to day use such as ropes and twines.

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Effect of Helium Density of Coal on Total Conversion and Benzene Soluble Product Yield in Hydrogenation and Models for Their Predictions

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In the process of hydrogenation, helium density of coal is found to be very important parameter. The total conversion and benzene soluble product yield are found to correlate linearly with helium density of coal. The total conversion is found to correlate with helium density with correlation coefficient of 0.97. The benzene soluble product yield is found to correlate with helium density, and wt per cent hydrogen with correlation coefficient 0.95.

Introduction

The hydrogenation of coal to liquid products has been investigated for several decades. In the context of genetic and structural development studies of coal, Mazumdar¹ reported that during the process of coalification, several reactions, such as, deoxygenation, dehydrogenation, methylation, demethylation, aromatic ring coalescence and cyclization are expected to occur. In a hydrogenation study, within the investigation range (Pressure, 8.6 MPa; Temperature, T-385 - 425°C), Given *et al.*² found the highest conversions for coals of high volatile bituminous rank. Oelert and Siekmann³ reported a linear positive relationship between the O/C ratio of coal and related materials and their conversions on hydrogenation. Mahajan *et al.*⁴ stated that hydrogenation of coal is essentially exothermic in nature and the evolution of heat is found to decrease with increase in the coal rank. He also mentioned that presence of pyrite has beneficial effect on coal hydrogenation. Cui and Sum⁵ found that iron-based complex catalysts yielded a higher hydrogenation activity for lignite liquefaction than that of a commercial Co-Mo catalyst. Redilich⁶ stated that coal reactivity in hydrogenation reactions is related to H/C ratio for the coal, even for a wide range of coals varying in rank and petrographic composition. They also stated that petrographic analysis could not help in understanding

the coal reactivity. On the other hand, King *et al.*⁷ suggested that H/C ratio is probably not sufficient to predict the reactivity for whole coals in hydro-liquefaction. Cebolla *et al.*⁸ also reported that there is no clear trend between H/C ratio and hydroliquefaction reactivity of coal. Kuznetsov *et al.*⁹ reported that the liquefaction behaviour is strongly influenced by coal rank and oxygen containing group of coals. Joseph¹⁰ reported that the conversion in the process of liquefaction depends on the coal rank and swelling agent and found to be maximum for bituminous coals.

Mitra *et al.*¹¹ studied the hydrogenation of bituminous coal in the presence of an iron catalyst without any external hydrogen donating solvent. He gave a number of correlations for predicting total conversion and benzene soluble products with lower values of correlation coefficients. He further stated that hydroxyl, carboxyl and carbonyl have high significance in the context of hydrogenation of coal. Atomic H/C ratio should be reliable parameter for correlation with hydrogen behaviour. Added to this hydroxyl, carboxyl, and carbonyl should also be significant parameters in the process of hydrogenation.

In relation to modelling studies Singh and Kakati^{12,13} obtained a number of good correlations (correlation coefficient values between 0.97 - 0.99) between sulphatic, pyritic, organic and total desulphurization efficiencies and atomic ratios of H/C,

O/C, and helium density. In another work, Singh and Kakati^{14,15} found good correlation between specific energy, and atomic ratios of O/C and O/H. For low rank coals, Singh¹⁶ has established a linear relationship between total acidity and atomic O/C ratio; and between carboxyl acidity and atomic O/C ratio, with correlation coefficient of high order. In another work, Singh¹⁷ established a linear relationship between acid equivalents of regenerated humic acid and atomic O/C ratio.

Gagarin and Krichko¹⁸ stressed the importance of statistical methods to study the influence of the nature of coal on hydrogenation behaviour. They further suggested to establish suitable empirical relationship, which can offer a powerful means for investigating the relationship between coal liquefaction behaviour, and its composition and structure. Helium density^{19,20} is an important fundamental property of coal, and it is related to the coal structure. In coal, it varies in systematic manner during coalification from lignite to anthracite. Recently, Singh and Kakati^{19,20} found good correlations ($r=0.96$ and 0.97) between helium density and atomic ratios of H/C, O/C and O/H.

In view of its importance and potentiality an attempt has been made in present study, to investigate the effect of helium density on coal conversion and benzene soluble products, and also to develop reliable models for their predictions.

Data and Methodology

Data for the investigation and development of various models are derived from Mitra *et al.*¹¹ work. Coal samples were hydrogenated at temperature = 673 K, pressure = 220 ± 2 kg/cm², and residence time = 3 hour, with a deposited iron catalyst and sulphur having atomic ratio of Fe/S = 0.2. Residue after release of gas was extracted with benzene in a soxhlet extractor. The ranges of ultimate analyses of the coals considered were carbon 76.7 per cent - 83.4 per cent, hydrogen 5.0 per cent - 5.7 per cent, nitrogen 1.0 per cent - 2.53 per cent, sulphur 0.13 per cent - 4.30 per cent, and oxygen 8.1 per cent - 15.8 per cent. Helium density of coals was calculated from models proposed by Singh and Kakati¹⁹.

Results and Discussion

Relationship Between Helium Density and Total Conversion

The interrelationship between helium density (HD_{dmnf}) and total conversion to benzene soluble product and gas in the process of hydrogenation is illustrated in Fig.1. It is evident from the figure that the relationship between these two variables is linear with a negative slope.

Regression, using the method of least squares, led to the following expression with a correlation coefficient of 0.97.

$$Y_{TC} = 368.1786 - 211.4936 (HD_{dmnf}) \quad \dots (1)$$

The relation between experimental and predicted values of wt per cent conversion computed by equation -1 is presented in Fig. 2. It is seen that the relation is linear with a slope of unity, indicating a good-fit.

Relationship Between Helium Density and Benzene Soluble Product Yield

Figure 3 presents the relationship between helium density (HD_{dmnf}) and wt per cent benzene soluble product yield. It is clear from the figure that the relationship between the two parameters is linear with a negative slope, indicating a reduction in benzene soluble product yield with increase of helium density of coal in the process of hydrogenation.

The linear relationship between related parameters obtained by regression methods is expressed through the following correlation with a correlation coefficient of 0.88.

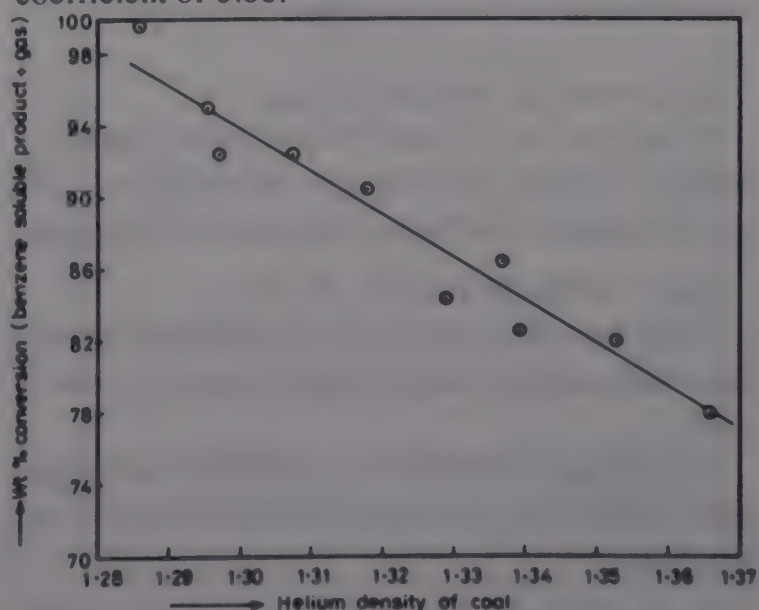


Fig. 1 — Relationship between helium density of coal and wt per cent conversion (benzene soluble product + gas)

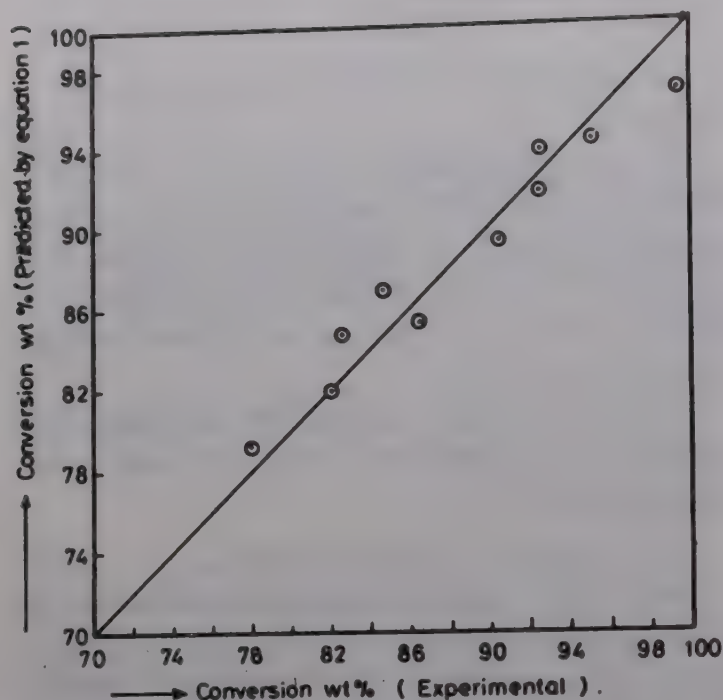


Fig. 2 — Relationship between predicted and experimental values of conversion

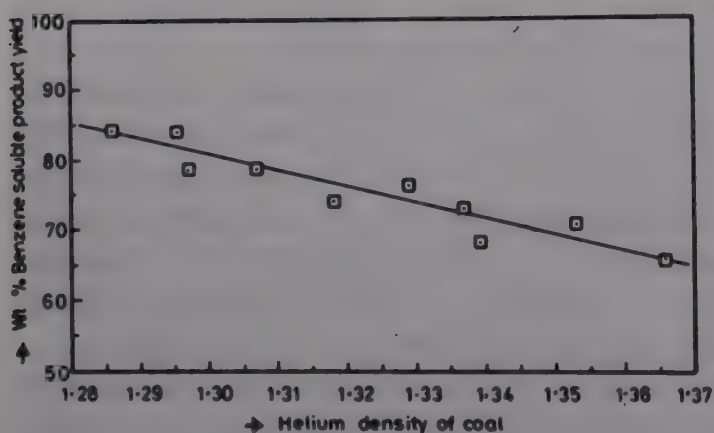


Fig. 3 — Relationship between helium density of coal and wt per cent benzene soluble product yield

$$Y_{BSP} = 679.93 - 456.96 HD_{dmmf} \quad \dots (2)$$

In the process of liquefaction by hydrogenation, benzene-soluble product was also found to have good correlation coefficient of 0.89 with hydrogen.

$$Y_{BSP} = 29.2(\text{per cent } H) - 82.13 \quad \dots (3)$$

Thus, benzene-soluble product yield can be correlated with helium density and hydrogen content of coal.

Accordingly, the following multiple linear regression model with correlation coefficient of 0.95 was obtained.

$$Y_{BSP} = 27.6497 + 15.7312(\text{per cent } H) - 27.7832(HD_{dmmf}) \quad \dots (4)$$

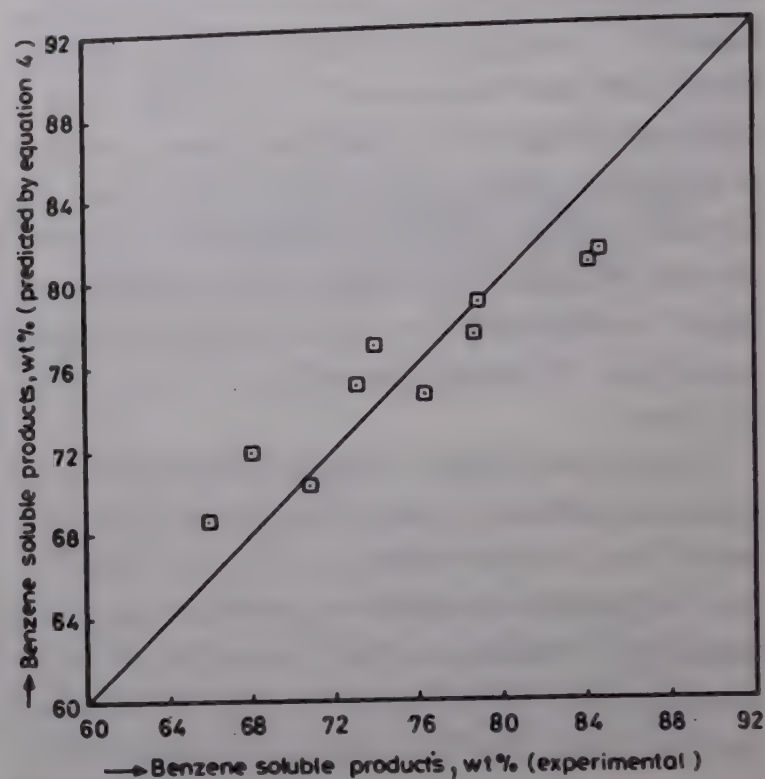


Fig. 4 — Relationship between experimental values of benzene soluble products and those predicted by Eq. (4).

The relation between experimental and predicted values of wt per cent benzene soluble product computed by Eq. (4) is presented in Fig. 4. It is evident from Fig. 4 that relation is linear with a slope of unity, indicating a good-fit.

Comparison of Models

Mitra *et al.*¹¹ gave a number of correlations for predicting total conversion and benzene soluble products. They reported the correlation coefficients in the value range of 0.80 to 0.93 for total conversion and from 0.79 to 0.89 for benzene soluble products.

The correlation coefficient for conversion computed by Eq. (1) is 0.97, greater than those for all the earlier models¹¹. The average absolute error by equation -1 is found to be 1.65 per cent against greater than 6.1 per cent by earlier models¹¹. Likewise, the correlation coefficient for prediction of benzene soluble products by Eq. (4) is 0.95, greater than those given by Mitra *et al.*¹¹

Conclusions

Hydrogenation has good potentiality to convert coal to liquid. Helium density of coal is found to be the key parameter in the process of hydrogenation. The strong linear relationship is found to exist between helium density of coal and total conversion. The strong linear relationship is also found to exist

between helium density of coal and wt per cent benzene soluble product yield.

The capacity of the newly developed models, particularly Eq. (1), to predict the total conversion in the process of hydrogenation of coal is proved to be excellent and superior to that of all the earlier correlations¹¹.

The capacity of Eq. (4), to predict the benzene soluble products during hydrogenation of coal is also found to be exceedingly superior to that of all the earlier¹¹ correlations.

The developed models will be of immense utility in predicting total conversion and benzene soluble product yield at given experimental conditions by knowing helium density of coals under interest.

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Studies On Glass Reinforced Melamine Laminates

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Various melamine formaldehyde resins have been synthesised by using different mole proportions of melamine and formaldehyde. Different catalysts such as triethyl amine, diethyl amine, triethanol amine, diethanol amine, and sodium hydroxide have also been used. Glass fabric has been incorporated in these resins for making composites. Physical, mechanical, electrical, and other properties have been determined. It has been observed that composites prepared by using melamine formaldehyde resins in molar ratios 1:1.75, catalysed with diethyl amine give better properties and finish.

Introduction

Melamine formaldehyde laminates have gained considerable importance as fire resistant, arc resistance, printed circuits panels, and switchgear¹. The M-F resin has also been used for decorative laminate for imparting abrasion resistance². The generally used basic laminating resin comprises melamine formaldehyde in ratio 1:2³. It is evident¹ from literature that no systematic study for the synthesis and characterisation of M-F resin and its laminate has been done so far. Hence, several M-F resins have been synthesised by using different catalysts and also by varying reactant ratios. The glass reinforced laminates have also been made for industrial and electrical applications. Various characteristics like physical, mechanical, and electrical properties have also been studied.

Experimental

Materials and Methods

Commercial grade melamine powder supplied by M/s GNFC, Gujarat and 37 per cent solution of formaline supplied by M/s Western India Chemicals were used for the synthesis of M-F resins. Diethyl amine, triethyl amine, diethanol amine, triethanol

amine, and sodium hydroxide were procured from E MERK (Vadodara). Glass fabric was supplied by M/s Procher Industries, France. It was fine weave type style 7628 having 0.17 mm thickness. The testing of laminates was carried out as per international specifications⁴⁻⁷ (e.g. BS, NEMA, IEC, and ASTM).

Preparation of Resins

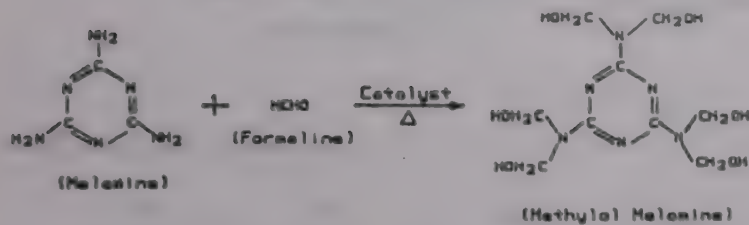
Initially, with the fixed ratio of melamine formaldehyde, few resins were synthesised separately by using catalysts, namely diethyl amine, triethyl amine, diethanol amine, triethanol amine, and sodium hydroxide. Further, after analysis of these results more resins were also synthesised by varying proportion of melamine and formaldehyde. The catalyst used in this case was diethyl amine. All the reactions were carried out in 1 L reaction assembly. To a known amount of formaline, an appropriate quantity of the catalyst was added. The pH was maintained between 8 to 10. Melamine powder was added into the solution slowly with continuous stirring. The reaction was carried out at 98-100°C for 30 to 60 min, with continuous stirring and was cooled rapidly to room temperature.

Preparations of Glass Laminates

Glass fabric was cut into size 300x300 mm. The resin was applied with the help of brush. Coated plies were dried in an air circulatory oven for 5 to 7 min at

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[#]A-10 Padmanabh Nagar, Govindpura, Bhopal 462 023, M P



Scheme 1—Condensation of melamine with formaline

130°C and then kept over each other and pressed at 155 to 160°C for 2h at a pressure of 70 kg/cm².

Results and Discussion

Condensation reaction takes place during the synthesis and curing of M-F resins. Generally, formaldehyde molecules react with amino groups of melamine in the presence of catalyst, as shown in Scheme 1. A simplified constitution of M-F resin in the final cured stage is shown in Fig. 1.

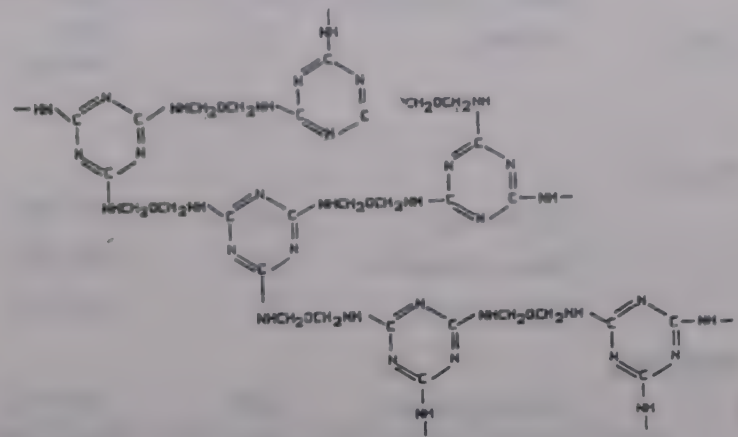


Figure 1—Cross-linked M-F resin structure

The properties of 3 mm thick glass melamine laminate prepared by M-F resin using M:F in the ratio 1:3 and different catalyst used are given in Table 1.

Table 1 — Characteristics of 3 mm thick glass melamine laminate using different catalysts

Sl No.	Property	Unit	Test method	Catalysts				10% aqueous solution of NaOH
				Triethyl amine	Diethyl amine	Triethanol amine	Diethanol amine	
Physical								
1	Specific Gravity	g/cc	BS-2782	1.91	1.91	1.94	1.93	1.91
2	Water absorption	%	BS-2782	1.25	1.05	1.15	1.19	1.27
3	Resin content	%	BS-2782	38.10	39.80	37.20	37.40	39.10
Mechanical								
4	Tensile strength	MPa	BS-2782	313.70	314.20	294.10	117.40	328.40
5	Cross breaking strength	MPa	BS-2782	98.00	166.60	98.00	63.72	117.60
6	Punch shear strength	MPa	BS-2782	137.20	181.20	166.70	147.00	196.00
7	Compression strength	MPa	BS-2782	509.80	607.80	--	490.10	609.20
Electrical								
8	Dielectric flatwise	KV/mm	BS-2782	8.00	8.00	6.20	4.50	4.00
9	Dielectric edgewise	KV	BS-2782	42.00	43.00	35.00	28.00	23.00
Special								
10	Arc resistance	s	ASTM D495	190.00	197.00	190.00	188.00	187.00
11	Comparative tracking index	Volts	IEC-112	600	600	600	600	600
12	Flammability	Class	UL - 94	Vo	Vo	Vo	Vo	Vo

Table 2 — Characteristics of 3 mm thick glass melamine laminate using different mole ratios of M-F
M : F molar ratio

Sl No.	Property	Unit	Test method	M : F molar ratio			
				1 : 2.5	1 : 2	1 : 1.75	1 : 1.5
<i>Physical</i>							
1	Sp. Gravity	g/cc	BS-2782	1.94	1.98	1.99	1.97
2	Water absorption	mg	BS-2782	121.00	89.00	107.00	114.00
3	Resin content	%	BS-2782	40.20	39.50	38.20	39.10
<i>Mechanical</i>							
4	Tensile strength	MPa	BS-2782	235.30	294.10	254.90	196.00
5	Cross-breaking strength	MPa	BS-2782	176.60	176.50	176.00	205.80
6	Punch shear strength	MPa	BS-2782	147.00	166.70	176.50	264.70
7	Compression strength	MPa	BS-2782	392.10	470.60	460.80	411.80
<i>Electrical</i>							
8	Dielectric flatwise	kV/mm	BS-2782	9.00	10.00	12.00	12.00
9	Dielectric edgewise	kV/25mm	BS-2782	46.00	54.00	55.00	55.00
<i>Special</i>							
10	Arc resistance	s	ASTM-0495	195.00	220.00	240.00	240.00
11	Comparative	Volts	IEC-112	600	600	600	600
12	Flammability	Class	UL-94	V ₀	V ₀	V ₀	V ₀

From Table 1, it is evident that glass laminates prepared by DEA catalysed resin give better mechanical and electrical properties with a little water absorption. It is also observed that these laminates have better surface finish. Further, to improve upon the properties obtained in DEA catalysed resins, a few more resins were synthesised by varying the melamine formaldehyde molar ratios i.e. 1:2.5, 1:2, 1:1.75 and 1:1.5, respectively. DEA was used as catalyst for all the resins. The properties observed in these sheets are compared in Table 2.

From the Table 2, it is evident that M-F resin containing lower ratio of formaline gives better cross-breaking, punch shear, and electrical values in laminates. Very high arc resistance value, i.e. 240 s, was observed in the resin having M-F ratios 1:1.75 and 1:1.5, respectively. It was observed that gradual decrease of the formaline ratio in the resin gives better finish and less water marks on the surface.

Concluding Remarks

Comparatively, better test results were observed in the M-F resin catalysed by DEA. The M-F resins prepared by lower ratio of formaline with melamine

can be successfully employed as a matrix in glass laminates for electrical applications. The M-F resins in ratios 1:1.75 and 1:1.5, possess a very high value of arc resistance which is a special feature and essential requirement of melamine formaldehyde resin.

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CONFERENCE REPORT

Thirtyfirst International Conference on Coordination Chemistry, Vancouver, Canada — A Report

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The 31st International Conference on Coordination Chemistry was held at Vancouver, Canada, at the beautiful and scenic spot of the University of British Columbia (UBC) during 18-23 August, 1996. The conference was inaugurated by the Chairman of the organising committee, Hon'ble Mr Chris Orvig (UBC), on 18th August 1996, who stressed upon the need for such conferences on coordination chemistry in order to evaluate the significance and its utility in the modern era. In all 850 delegates took part in the deliberations at this conference.

Plenary Lectures

Besides the technical sessions at the conference, there were six plenary lectures, delivered before the start of the morning sessions, by special invitees on diverse topics in coordination chemistry. The first lecture was delivered by W. G. Klemperer (Department of Chemistry, University of Illinois, USA), who dealt at length the two-dimensional coordination chemistry in self-assembled inorganic monolayers. Explaining the versatility of self-assembled organic monolayer chemistry as a facile route functionalized surfaces through incorporation of various organic functional groups into the adsorbate molecules, he stressed more on the recent discovery of polyoxanions that spontaneously form monolayers on silver (III) surfaces which presented the first ever example of inorganic monolayer assembly.

The second lecture was delivered by B.R. James (UBC, Vancouver, British Columbia, Canada) on "Coordination Chemistry and Catalytic Conversions of H_2S ". In this lecture, Prof. James discussed the transition metal- H_2S chemistry, stressing more on Ru chemistry. He pointed out that reactions of H_2S with Ru(0) species yield the expected hydrido (mercapto) ruthenium(II) complexes, but the 5-coordinate precursor $RuCl_2(PPh_3)(P-N)$, where P-N is the chelating ligand $Ph_2P(o-C_6H_4NMe_2)$, binds H_2S reversibly to generate $RuCl_2(PPh_3)(P-N)(SH_2)$, which have been characterized by X-ray crystallography.

The third lecture by C.D. Garner (Manchester University, Manchester, UK) focussed on the X-ray Absorption Spectroscopic Studies (XAS) of metal centres in biology and developments of relevant synthetic analogues, citing applications of XAS in probing the local environment of transition metal centres in metalloproteins. E. Kimura (School of Medicine, Hiroshima University, Kasumi 1-2-3, Minami-ku, Hiroshima, Japan) delivered an absorbing lecture covering the applications of macrocyclic metal complexes in the selective recognition of nucleic acid bases and in manipulation of gene expression, followed by a lecture delivered by L. F. Lindoy (School of Molecular Sciences, James Cook University, Townsville; Queensland) on tailoring macrocycles and molecular assemblies for metal ion binding. Prof. Lindoy emphasized on the potential industrial appli-

cations of such systems, specifically in solvent extraction studies. The last and final plenary lecture was addressed by R. R. Schrock (Massachusetts Institute of Technology, Cambridge, MA, USA) on a topic which is considered to be highly significant from the coordination point of view. It described the importance of high oxidation state coordination chemistry with special reference to triamidoamine-tungsten and -molybdenum complexes.

Technical Sessions

The deliberations at the conference were held under the following subsections:

- (1) Metal Centres in Biology and Medicine
- (2) Mechanistic Insights
- (3) Activation of Small Molecules
- (4) New Materials
- (5) Multidentate Ligands and Supramolecular Assemblies
- (6) Electronic Properties: Theory and Practice
- (7) Environmental Chemistry : Initiatives and Applications
- (8) Main Group Chemistry, and
- (9) Advances in Molecular Structure and Design

Each technical session comprised session lectures as well as oral and poster presentations.

Session 1: Metal Centres in Biology and Medicine

The four guest lectures delivered in this session were presided by many distinguished personalities from the scientific world. The first lecture by M. J. Abraham (Johnson Matthey Inc., West Chester, PA, USA) was on "Ruthenium Complex Scavenging of Nitric Oxide in Biological Systems". He outlined the potential therapeutic value of molecules such as ruthenium complexes that scavenge nitric oxide, a contributory factor in a variety of disease states such as septic shock, inflammatory bowel disease and arthritis.

The second lecture by Peter J. Sadler (Birkbeck College, University of London, UK) was entitled "Metallodrugs: Design and Mechanism of Action". The third lecture was by E. I. Solomon (Stanford University, California, USA) who presented a brief account of the electronic structure contributions to bioinorganic chemistry citing blue copper active site in biological systems as an experimental evidence to

support this theme. In his brief but informative talk, he explained that the copper sites in biology exhibit unique spectral features which reflect novel electronic structures making key contributions to the reactivity. The concluding guest lecture of this session, delivered by D. Sellmann (Institut für Anorganische Chemie der Universität, Erlangen, Germany) was by far on the most engrossing theme of the session with the focus on "Biological Challenges to Coordination Chemistry: Modelling the Reactivity of Nitrogenase and Other Metal Sulphur Enzymes". In his lecture, Prof. Sellmann pointed out that modelling the reactivity of metal enzymes is the search for low molecular weight complexes that act as catalysts. Such complexes should be stable in the absence of proteins, robust towards decomposition by enzyme substrates but highly reactive in order to be catalytically active.

In oral presentation session, 29 papers were presented. The first paper by Thomas J. McMurray (Metalsyn Inc, Cambridge, MA, USA) described the coordination chemistry of albumin-bound magnetic resonance imaging contrast agents. The next paper by T. J. Meade (California Institute of Technology, Pasadena, CA, USA) was focussed on the novel peptide-modified cobalt chelate complexes: selective and irreversible inactivation of human thrombin. It was pointed out in this paper that these cobalt complexes inhibit the replication of ocular forms of the herpes virus. In the next paper, Youn Soo Sohn described the synthesis, structure and antitumour activity of diamineplatinum(II) complexes of allyl malonate derivatives. He informed that he had observed a high antitumour activity against leukemia L1210 cell line for the (0,0') - chelate of diamineplatinum(II) with allylbenzylmalonate. In his paper, Natalia N. Zheligovskaya (Moscow State University, Moscow, Russia) described the mechanism of antitumour action of Pt(IV) complexes. His investigations revealed a wide spectrum of antitumour action shown by oxoplatin. The next paper was by Roger Schibli (Division of Radiopharmacy, Villigen, Switzerland) who explained the importance of organometallic compounds, with stable elements or radioactive isotopes, in medicine or nuclear medicine. He described the synthesis of complexes of the type $[MX_3(CO)_3]^{2-}$ from $[MO_4]^-$ where $M = {}^{99}Tc$ or ${}^{133}Re$ ($X = Cl, Br$) and emphasized on their potential

applications in radioimmunotherapy as well as radioimmunodiagnosis. Other papers which drew lot of interest were the ones presented by H.R. Maecke (Institute of Nuclear Medicine, Basel, Switzerland) and R.L. Richards (John Innes Centre, Norwich, UK) entitled "Silver (I) Complexes of New N_4S_4 and N_3S_3 Macrocyclic Ligands and Crown Thioether Complexes of Vanadium (II), Vanadium (III) and Vanadium (IV)", respectively.

A large number of papers, numbering 74, were put up for the poster presentations at this session, and quite a few of them created interest amongst the enthusiasts. The papers singled out for special mention are the ones presented by Stephen M. Lacy (University of Glasgow, Glasgow, UK) entitled "Synthesis and Biological Evaluation of Novel Cobalt-based Anticancer Prodrugs"; T. Takayama (Kanagawa University, Rokkakubashi, Yokohama, Japan) entitled "Structural Analysis of Modified Metalloprotein, Cadmium-glycylglycine Complexes Studied by X-ray Diffraction and High Resolution ^{113}Cd and ^{13}C Solid NMR"; Jeffrey J. Posakony (UBC, Vancouver, British Columbia, Canada) entitled "Porphyrins and Metalloporphyrins: Synthesis, Characterization and Evaluation as Chemotherapeutic Agents in Cancer Therapy"; and Jide Xu (University of California, CA, USA) entitled "Uranyl Ion Sequestering Agents — Design, Structural and Biological Evaluation", to name a few.

Session 2 : Mechanistic Insights

Out of the five guest lectures delivered at this session, the significant ones were by H. Ohtaki (Department of Chemistry, Ritsumeikan University, Kusatsu, Shiga, Japan) on "Structure of Intermediates in the Metal Substitution Reactions of Mercury(II)- Porphyrin Complexes with Divalent Transition Metals Determined by the Stopped-flow XAFS Method" and by J. Espenson (Iowa State University, Ames, IA, USA) explaining "The Mechanisms of Reactions Catalyzed by Methyl-rhenium Trioxide".

The 17 oral presentations in this session encompassed authors from all corners of the globe, though only a few of them could leave a deep impression. Amongst these were the presentations by G. Lawrence (University of Newcastle, Callaghan, Australia) entitled "Novel Tri- and Tetravalent Ruthenium and Osmium Prophysis Complexes and

Mechanism of Their Formation from the Metal(II) Carbonyls", and by S. H. Bergens (University of Alberta, Alberta, Canada) focussing on "[Ru(R)-2,2'- bis(diphenyl phosphino-1,1'-binaphthyl)(H)(MeCN)/(Sol) $_2$ (BF $_4$) (Sol = MeCN, THF or Acetone) — A Reactivity Survey and Observations of likely Intermediates in Enantioselective Catalytic Hydrogenation".

Out of the 46 poster papers presented in this session, only a few presented the mechanistic insight of coordination chemistry involved in their studies. The presentation by D.B. Leznoff (UBC, Vancouver, BC, Canada) centering around chromium organometallic complexes, was full of substance and described the coordination of tridentate amidodiphosphine ligand to a Cr(II) centre giving four and five coordinate paramagnetic complexes. The paper by J. A. Olabe (Universidad de Buenos Aires, Capital Federal, Republica Argentina) entitled "The Coordination of Sulphur Containing Ligands into $[\text{Ru}^{\text{III}}(\text{EDTA})(\text{H}_2\text{O})]$ " also drew lot of interest, in which mechanistic significance of the nucleophilicity of thiols and the influence of steric effects were discussed. Another paper by Andrew Pateman (University College, London, England) entitled "Copper Complexes as Catalysts for Olefin Aziridination" explained the synthesis and uses of copper complexes as catalysts for promoting the aziridination of olefins by nitrene transfer. The best paper of this session, however, was from M. Matsumoto and H. D. Takagi (Nagoya University, Japan) who described in their paper "Homogeneous and Heterogeneous Electron Transfer Reactions of Bis(1,4,7- Trithiacyclononane) Palladium(III/II) and Gold(III/II) Couples". It described the oxidations of bis(1,4,7-trithiacyclononane) palladium(II) and bis-(1,4,7-trithiacyclononane) gold(II) complexes by an outer sphere oxidizing agent in aqueous acidic solution. The relationship between homogeneous and electrochemical exchange rate constants were also discussed.

Session 3 : Activation of Small Molecules

Five dignitaries delivered their lectures in this Session. The best was the lecture delivered by J. Costamagna (Universidad de Santiago de Chile, Santiago, Chile) on "Complexes with Azamacrocyclic Ligands Active for the Reduction of Carbondioxide",

describing the electrochemical and pulse radiolysis reduction processes observed for carbondioxide in the presence of cobalt(II), nickel(II), or copper(II) complexes with polyazamacrocyclic ligands. The lecture by Pierre Braunstein (Universite Louis Pasteur, Strasbourg Cedex, France) was equally informative. He talked about the bimetallic synthesis and reactivity of silyl or stannyl ligand incorporated heterometallic transition metal complexes.

Out of the 19 oral presentations in this session, only four could be regarded excellent presentations due to their significant contribution to the advancement of coordination chemistry with wide applications. T. B. Karpishin (University of California, San Diego, California, USA) in his paper, "Tetraazaannulene Complexes for the Catalytic Reduction of Carbondioxide" described the synthesis of a series of nickel complexes with the tetramethyltetraazaannulene ligand framework and their use in the photocatalytic reduction of CO₂. K. Tani's (Osaka University, Osaka, Japan) paper entitled "Activation of Methanol with Rhodium(I)- and Iridium(I)-BINAP complexes: Isolation and Characterization of a Stable Hydrido(methoxo) Iridium(I) Complex" described the efficiency of the above complex as a catalyst for transfer hydrogenation of alkynes and asymmetric hydrogenation of imines. The paper by R. H. Morris (University of Toronto, Ontario, Canada) entitled "Protonation at a Thiolato or Cyano Ligand and then at a Hydrido Ligand to give New Dihydrogen complexes of the Iron Group Metals" described the study of protonation reactions for exploring the existence of other thiol tautomers of the type [Os(H)(CO)(quSH)(PPh₃)₂]⁺ where quSH = quinoline-8-thiol. In his paper, W. I. Evans (University of California, California, USA) described the synthesis, structure and reactions of tris (pentamethylcyclopentadienyl) lanthanide complexes and their implications in sterically crowded coordination chemistry in general. These papers were certainly worth an applause.

The poster presentations in this session had in all 56 papers. Some of these could be singled out for their vivid and informative presentations. One of the most laudable presentation of the session came from T. J. Kim (Kuyungpook National University, Taegu, Korea) who described some new routes to the formation of a series of ferrocene containing

polyazamacrocycles and related chelate bidentate ligands and the synthesis of their Cu(I) and Cu(II) complexes, which were found to be efficient catalysts for the formation of carbamates and cyclic carbonates via CO₂ activation. The other worth mentioning papers were the ones presented by E. L. Blinn (Bowling Green State University, Bowling Green, Ohio) entitled "The Photo and Electro Reduction of Carbondioxide using Nickel(II) Complexes as Catalysts"; L. I. Simandi (CRI, Hungary Academy of Sciences, Budapest, Hungary) entitled "Activation of Dioxygen by Cobaloxime (II) Catalytic Biomimetic Oxidations via Free-Radical Intermediates"; and G. Cairns (University of Glasgow, Glasgow, UK) entitled "Highly selective Catalysts from Silica Supported Palladium Phosphine Complexes".

Session 4: New Materials

All novel coordinate compounds/complexes synthesized by various methods were included in this session. Of the four session lectures, the one by M. P. Andrews (McGill University, Quebec, Canada) was highly informative and orchestrated around the theme of getting molecules and mesoscale objects to interact with light in ways that are both interesting for both chemistry and optical devices. He adopted a "bottom up" molecular chemistry/spectroscopy approach in reviewing the progress on transporting Er³⁺ via molecular vehicles to sites in photoinscribed hybrid sol-gel glass waveguide devices. It also explored the use of molecular self-assembly techniques to build mesoscopic waveguide "optical chemical benches" and fractal waveguide composites from noble metal nanoparticles. The other three lectures were also equally informative with talks on new materials invented/possible ones with potential applications in diversified fields.

The oral presentations in this session included 11 papers of which the best paper entitled "Synthesis and Characterization of Macrocyclic Lyotropic Liquid Crystals" was presented by I. A. Fallis (University of Wales, Wales, UK). It described the coordination chemistry of 1,4,7-triazacyclononane and several of its pendant arm derivatives.

Of the 21 research papers included in the poster presentation, the paper that demands a special mention for its quality and presentation, was by Deryn E. Fogg (MIT, Massachusetts, USA). It described the development and optimization of a suitable cluster

sequestering block, in which modified norbornene monomers, polymerized by ring-opening metathesis polymerization (ROMP) methods, mimic and displace the phosphine groups passivating the surface of prefabricated CdSe nanoclusters.

Session 5: Multidentate Ligands and Supramolecular Assemblies

This session had 4 guest lectures and 46 oral presentations with an unimaginable figure of 139 papers for poster presentation.

The guest lecture delivered by S F Lincoln (The University of Adelaide, Adelaide, Australia), was most interesting. It explained the significance of pendant arm macrocyclic ligands in coordination chemistry. Pendant arm macrocycles were initially developed with a view to improving the metal ion selectivity for polyaza and polyoxa macrocycles and modifying the lability of the resulting complex ions. He explained the structural equilibrium and mechanistic aspects of pendant arm polyazacycloalkane complex ions and stressed upon the fact that the coordinating properties of triazacyclononane combine with the complexing properties of β -cyclodextrin to produce ternary complexes that exhibit an interesting range of stereochemical and other properties.

Almost all papers presented in the oral presentations were good and had lot of substance in them. However, the paper by S. J. Loeb (University of Windsor, Ontario, Canada) entitled "The Self-assembly of Metal-based Molecular Hexagons" could be singled out for a special mention. It reported the synthesis, DNMR studies and X-ray structures of the organometallic coordination polymers prepared from a series of 1,4-dipalladiated durene-based thioether ligands and 4,4'-bipyridine as the linking fragment.

All the papers presented in the poster presentations in this session were quite informative. However, the papers by G. Wei (The University of Newcastle, NSW, Australia) entitled "Synthesis of a New 36-Membered Macrocyclic Bis-dithiamine Ligand, Crystal Structure of the Dinuclear Dicopper(I) Complex"; J. Quirk (University of Southampton, Southampton, UK) entitled "Coordination Chemistry of Platinum and Palladium with Macrocyclic Selenoether Ligands" and A. de Blas (Universidade

de A, Coruna, Spain) entitled "Mass Spectrometry Evidence for Some Homo-binuclear Complexes of Lanthanide(III) Ions with Macrocyclic Ligands" need special mention.

A large number of papers were displayed in the poster presentations of this session. The author Sheela P. Malve (Institute of Science, Mumbai, India), also presented her paper entitled "Structural Studies of Some Metal Complexes of 5-Isopropylidene-1-Methyl-2,4-Dithiobiuret Hydrochloride". It described the synthesis of metal complexes of Co(II), Ni(II), Cu(II), Zn(II), and Cd(II) with 5-isopropylidene-1-methyl-2,4-dithiobiuret hydrochloride and structure elucidation using chemical, magnetic and spectral studies. Their antimicrobial activity has also been studied.

Session 6: Electronic Properties: Theory and Practice

Out of the four session lectures delivered by special invitees, the one that created lot of enthusiasm was delivered by Oliver Kahn (Institut de Chimie de la Matière Condensée de Bordeaux, Pessac, France). It focussed on the topic "Molecular Magnetism : A New Challenge for Coordination Chemists".

The oral presentations at this session included 12 papers of which the one by Christoph Elschenbroich entitled " $(\eta^7\text{-Cycloheptatrienyl})$ (Carboxy- $\eta^5\text{-Cyclopentadienyl})$ Vanadium — A Versatile Paramagnetic Organometallic Carboxylic Acid to Explore Electron Spin Exchange Phenomena" attracted the attention of most of the participants. It described the synthesis of TVC-COOH that represents a novel paramagnetic organometallic carboxylate ligand which may be used for the construction of multispin units.

Out of 26 papers displayed at the poster presentations, the paper by A. Claudia (Université de Fribourg, Fribourg, Suisse) entitled "Influence of Substituents on the Electronic Structure of Bis(thienylpyridine) Platinum(II): Model Calculations with Density Functional Methods" generated lot of interest amongst participants.

Session 7: Environmental Chemistry: Initiatives and Applications

This session comprised four session lectures, seven oral papers and eight poster presentations.

The session lecture by O. F. X. Donard (Universite de Pau et des Pays de l'Adour, France), on the topic "Environmental Aspects of the Geochemistry of Sn, Se, and As in Marine Ecosystems" was highly informative. Prof. Donard illustrated, taking examples from environmental biogeochemistry of Sn, Se, and As, the fundamental role of alkylation and dealkylation processes with respect to the fate and impact of these metals and metalloids in marine ecosystems.

Two papers out of the seven oral presentations, need mention for their content. These were by D. Max Roundhill (Texas Technical University, Lubbock, USA) entitled "Extraction of Heavy Metals by Calixarenes Derivatized with Sulphur Groups" and by J. Feldmann (UBC, Vancouver, BC, Canada) on "Environmental Studies on Volatilization of Metal(lloid) Compounds by using GC-ICP-MS".

Session 8: Main Group Chemistry

In this session, out of four session lectures delivered by special invitees, the one by H. Schmidbaur (Technische Universitat, Munchen, Garching, Germany) entitled "Metalloids in Multinuclear Metallo Complexes" was quite informative. In his brief talk, he stressed on the significance of metallo complexes in coordination chemistry, pointing that "Metallo Complexes" are the inverse of common "metal complexes" in that they feature a set of metal atoms M clustering around a non-metal or metalloid centre E to give aggregates of the general formula $[EM_n]^{m+}$.

The session also had 9 oral and 23 poster presentations. In the two interesting papers in the poster presentations of this session, one described the synthesis and spectroscopic characterization of new triphenyltellurium derivatives of organophosphorus ligands (by Anea Silvestru, Babes Bolyai University, Romania) and the other highlighted the lead(II) complexes of multidentate schiff bases ligands (by A.T. Ross, Loughborough University of Technology, Loughborough, Leicestershire, UK).

Session 9: Advances in Molecular Structure and Design

This last session had four guest lectures of which the one by F. E. Hahn (Freie Universitat Berlin, Berlin, Germany) describing the coordination chemistry of ligands with subvalent group 14 donor atoms (multidentate isocyanides, carbenes, and stannylene) was the most interesting. Also, the talk by M.

Peruzzini (Istituto per lo Studio della Sterochimia ed Energetica dei Composti di Coordinazione, Florence, Italy) which dealt with the synthesis of aminophosphine ligands and their organometallic chemistry in combination with transition metals, had some novel information.

There were 31 oral papers and 67 poster presentations in this session. All the papers were excellently presented with lot of substance in them and being very materialistic in character.

The conference concluded on 23rd August, 1996 when representatives of Chile, for the 32nd International Conference on Coordination Chemistry (I.C.C.C.) and Italy, for the 33rd I.C.C.C., extended invitations to the delegates.

Conclusion

To sum up, the conference was a runaway success with some of the best papers presented and lectures delivered by eminent scientists from all corners of the globe. The various presentations are indicative of the popularity and significance of coordination chemistry and its applications in diversified fields of study. Of late, metal complexes are the most sought after inorganic compounds which have a wide range of applications in diverse fields as medicine, industry, photochemistry, biology, environment/analytical chemistry and many more. The coordination compounds also play a significant role in the pharmaceutical chemistry. Many pharmaceutical companies have realized the potential of coordination compounds in the treatment of various dreadful diseases. Platinum complexes have evoked lot of interest amongst coordination chemists because of their utility as antineoplastic agents. For example, a paper published in the journal, *Inorganica Chimica Acta* [241 (1996), 104], entitled "Synthesis and Antitumor Activity of New Trans-1R, 2R- Diaminocyclohexane Platinum(II) Complexes Containing Disubstituted Sulfide Groups" by Abdul R. Khopkhar (The University of Texas, M. D. Anderson Cancer Centre, Houston, USA), described the synthesis and characterization of the platinum(II) complexes and its antitumor activity. Also, selenium complexes are gaining popularity as potential anti-neoplastic and anti-HIV agents.

Many arsenical coordination compounds are also finding applications in medicinal chemistry. Similarly, several metal complexes with ligands contain-

ing N, O and S are useful as antimicrobial agents and antitubercular agents. Coordination compounds are also used as catalysts to execute different type of reactions. For example, a paper published in *Indian Journal of Chemistry* [35A (1996) 960-3] entitled "Kinetics and Mechanism of Oxidation of Two New Chromium(III) Complexes by Hydrogen Peroxide" by S. C. Pal (Karnataka University, Karnataka, India), describes the kinetics and mechanism of oxidation of H_2O_2 using two Cr(III) halo schiff bases and many more. Thus, in the near future one can expect more contributions from coordination chemists to science for the benefit of mankind.

Acknowledgement

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BOOK REVIEWS

Industrial Economics for Countries in Transition: Evidence from Eastern Europe and Asia Pacific, edited by Philippe R Scholte's (Edward Elgar, UK) 1996, pp 224, Price: £ 45.00 [ISBN 1 85898 521 8]

Many developing countries that began imitating the practices of economic management of socialist countries became orphaned after the collapse of centrally controlled economics of the socialist world. New buzz words are globalization and liberalization. Along with the developing countries, joined countries of collapsed socialist block and also socialist countries (like China and Vietnam) that wanted to avoid collapse. There is a new found efficacy in market driven economic system. Emphasis is on bringing back market forces for efficient management of an economy. These are the countries in transition. Problems these countries face are different not only in terms of magnitude but also in terms of their nature. Countries from collapsed socialist block face the problem of creating market environment, whereas for other developing countries it is strengthening the dormant or weak market forces. Again, problem of transition is different in China and Vietnam compared to their counterparts in the erstwhile socialist blocks or rest of the developing world.

China and Vietnam have adopted a gradual and selective process of privatization of their respective controlled economies. Woes of transition are much less in these countries compared to the countries in socialist block where the earlier economic edifices have become totally shattered; and a quick transition process is to be enforced to save these countries from sociopolitical disaster. Hungary, among them, again is a different case because the transition process began there long before the fall of socialist world. Erstwhile GDR offers again a separate case from the rest. The transition process there has been managed by the strong economy of FRG—the other side of Germany before the fall of Berlin wall.

The book under review deals with these most challenging economic and social problems of the outgoing century. Part 2 of the book deals with a master plan for industrial development of Red River

Delta of Vietnam. The link between Part 1 and 2 of the book is not very apparent. The foreword of the book also does not claim any link, whatsoever, between the two parts. The foreword of the book, however, claims a logical sequence in six chapters included in Part 1. The sequence is not very clear. Chris Rodrigos lucid theoretical discussion on issues related to transition is rarely reflected in the subsequent chapters like "a synthesis of literature", Eastern European lessons, or managerial issues related to privatization of public enterprises discussed by Gokgur. Lufts description of German experience is too short and flashy to be sequenced with discussions on game theoretic approach of decision making problem of technology transfer to the developing countries.

Chris Rodrigo's main emphasis is on the process of skill accumulation. He has argued that skill accumulation greatly contributes to productivity growth. Accumulated skill, according to Rodrigo, is non physical capital that can be separated into human capital and social infrastructural capital. And he has seen the purpose of economic reform in generating conditions that will bring about faster accumulation of this non-physical capital.

Strikingly, this main aspect of economic reform remained out of focus in all subsequent chapters and thereby missed the connecting thread to run through other chapters.

Gatsio's chapter on lessons from Eastern Europe brings out importance of social and political aspects of transition. Three important lessons drawn are: (a) Introducing new sets of economic institutions, (b) Transition with highest possible degree of social consensus, and (c) Transition as a gradual process. Gokgur's article deals with the efficient management of restructuring public enterprises and privatization. Four basic principles suggested are: (a) The process of restructuring has to work within a competitive environment and capital markets, (b) establishment of a well functioning legal and regulatory framework, (c) establishment of dedicated institutions for monitoring the process, and (d) defined role of gov-

ernment. These are actually the lessons which could be drawn from German experience of restructuring through Treuhandanstalt. The whole process revolved around the issue of speed of privatization and balancing it with potentiality of job creation and training and retraining of the industrial manpower.

Next two chapters of Part 1 are contributed by Scholte's; the editor of the volume. In the chapter on multi-agent decision making for economic reforms he brings in the question of market failure and suggests a new role of government in an emerging scenario for economies in transition. Main roles delineated by him are: (a) support for building up enterprise competitiveness, (b) developing a management system to make public enterprises more market responsive, (c) monitoring the privatization process, and (d) building up and enforcing the regulatory system.

This is followed by an essay on capital inflows and technology transfer in the developing countries. After discussing the various patterns of capital inflows and technology transfer, issues related to policies requirements of the developing countries have been highlighted. Author suggests two forms of policy supports from the government: (i) functional interventions and (ii) selective intervention. Functional intervention is basically to circumvent market failures. Selective intervention, on the other hand, is to augment limited resource mobilization capability of the developing countries.

All the essays mentioned above have taken the market failure aspect into consideration and tried to define the role of institutions and government in terms of management of market failure or restoring market efficiency. Market failure view, however, belongs to the same stable where market is considered as a passive set of rules which, in its best, should be able to direct economies to most efficient resource allocation and optimum pricing. The other view of market is organized and objective interactions and Co-ordination of various actors in economic activities. This view of market is likely to have great potentiality in planning transition of centrally controlled economies. Hopefully, future works in this field would further articulate the role of market in shaping the economies in transition or how market is shaped by economies in transition.

Literature on the problem of economic transition is still at a nascent stage. Experiences of a full scale transition are also not many. Cases of economies in transition are also not uniform. As we have discussed at the outset, there is no uniform European or Asia Pacific experience. All the cases are different from each other in terms of the existing status, intensity of the problem, and political environment. A generalization of the transition problem would require several case studies and theoretical refinement of many concepts like skill and related issues, organization vs market, governance and management issues related to transition, etc. The present volume is a significant contribution to the present pool of limited knowledge addressing the problem of transition, and would be a useful source book for policy makers and students of economic transitions.

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Economic Restructuring, Technology Transfer and Human Resource Development, by B R Virmani and Kala Rao (Response Books, A Division of Sage Publications, New Delhi/Thousand Oaks, London) 1997, pp 288, Price : Rs 395 [ISBN 81 7036 585 6 (hb)]

Economic restructuring, technology transfer and human resource development, according to the authors, are interrelated issues which must be tackled in a systematic manner by any country aiming to be globally competitive. Their argument, is based upon a comprehensive study of Singapore, Malaysia, Thailand, and India as well as detailed case studies of a few selected organizations.

The book comprises four parts. In the first part the authors present the concept and definition of technology transfer, human resources and economic development. It also describes in detail the policy issues connected with economic restructuring, globalization, regionalization, and their relevance to technology transfer. The second part gives a detailed description of the experiences of four Asian countries, namely, Malaysia, Singapore, Thailand, and India with regard to their economic restructuring. Micro-level case studies of selected organizations from India and Malaysia are presented in Part 3 along with a description of the different approaches followed by these organizations to technology transfer

and human resource development. The lessons drawn from the macro-level and micro-level studies described in Part 1 and 2 are presented in Part 4 along with some suggestions to improve the processes of technology transfer, human resource development, and economic restructuring.

Malaysia was a British colony until its independence in 1957. Till then Malaysia's economy was dependent on agricultural produces such as cocoa, rubber, palm oil, and minerals, e.g. tin. However, in about four decades, Malaysia has progressed to such an extent that the World Competitiveness Report accorded Malaysia the highest marks for a highly conducive business environment, attitude to work, technology, government, and international influence. In 1991, in terms of ratings of investment risks in selected economies by the International Country Risk Guide, London, the Malaysian economy's rating comes almost close to the developed countries such as the US, Japan, and Singapore. This has been made possible through the successive economic reforms followed by the Malaysian government to create a conducive environment for attracting foreign investment, the streamlining of the policies and procedures for quick approval of technology transfer and the steps taken for human resource development.

In 1963, when the British left Singapore, it became a part of Malaysia. It separated to become an independent country in 1965. Immediately after independence, the government took up the major responsibility of building and developing basic infrastructural facilities such as the sea port, airport, transport system, industrial estates, a reliable modern communication network along with economic liberalization. Lack of an internal domestic market necessitated export oriented production. The Singapore government followed a policy of encouraging foreign investment up to 100 per cent, provided 50 per cent of the products are exported. In the World Competitiveness Report of 1995, Singapore was ranked at number two position and in 1996 Singapore was declared a developed country. The government of Singapore has followed certain fundamental principles for economic development, such as ensuring a good, corruption-free government, encouragement to free enterprise, building an efficient infrastructure, heavy investment in education and training, maintaining a clean environment, an exemplary legal sys-

tem and fiscal prudence to build up national reserves. Because of the government's positive policies, Singapore — a city-state actually — has become in three decades after independence, a healthy economy to be emulated by any country wishing to be a global player.

Thailand, the only Southeast Asian country never colonized, has a constitutional monarchy which has been able to maintain political stability. Thailand's dramatic growth from an agricultural economy based on rice, rubber, tin, and teak to tourism and manufactured goods such as textiles, automobiles, and garments has been attributed to the government's efforts in providing infrastructural facilities such as roads, power generation, and irrigation projects. Thailand was able to attract foreign investors by offering a highly conducive environment and relatively low government interference. Though the Thailand economy has been growing, it has not yet developed a strong policy encouraging the growth of science and technology. Also there is no planned policy for development, assimilation, and upgradation of technology.

India began thinking in terms of industrialization only after its independence from the British rule in 1947. However, due to its colonization for more than a century, India developed a fear psychosis regarding the entry of large foreign companies, resulting in the adoption of an extreme position of becoming self-reliant and a fully protected economy and followed the socialistic pattern of planning. Owing to this inward looking approach, foreign trade in India was insignificant and foreign investment was discouraged. Many state enterprises started after independence were inefficient and loss making while an oppressive system of industrial licensing throttled the private sector. Only during the 1980s, some moderate efforts were made to liberalize the economy resulting in a gradual shift from import substitution to export orientation, reforms in capital markets, and licensing systems. In 1991, a new phase of reforms was implemented which included encouragement to private industry, foreign investment, liberalization of interest rates, elimination of import licensing, etc. It will take sometime before these reforms produce results, provided these are not reversed by a change in government.

The authors clearly demonstrate through the four country and organizational cases, the importance of technology development, foreign investment and building of human resources for economic growth and development. The cases also bring out certain common features that determine the efficacy of technology transfer and human resources development while revealing at the same time, the differences and peculiar features relevant to each country. The authors are quick to point out that the lessons drawn from the experiences of countries such as Malaysia, Singapore and Thailand may not be applicable *in toto* to a large country like India. However the need of the hour for the developing countries is to gradually integrate themselves with the world economic system and develop its own short-term and long-term strategies relating to economic and structural read-

justments, technology policies, and human resource development.

The present book does not bring anything new to experts in the field. However, it covers all the relevant material in a cogent manner, cites good examples, and gives prescriptive measures for implementation. The authors target their work at policy makers, planners, HRD managers as well as those involved with technology transfer. The book, with its excellent get-up, provides the necessary inputs to them, if they can spare the time and effort to read, digest and act.

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SCI-TECH UPDATE

European Union accords priority in S&T investments

That the European Union gives high priority to investments in science and technology, is reflected in a new Science Resources Studies (SRS) report, "Human Resources for Science and Technology: The European Region", (NSF 96-316) presenting data on the rapid growth of academic degrees and R&D financial support that indicates that a high concentration of the world's scientific resources continues to reside in Europe. (The growth of science and engineering resources in Asia was analyzed in a previous companion volume, "Human Resources for Science and Technology: The Asian Region" (NSF 93-303).

It is seen that over the 17-year period examined, the countries covered in the report collectively more than doubled their annual production of first university NS&E degrees.

First university degrees in NS&E fields awarded by institutions in Western and central Europe totaled almost 300,000 in 1992, compared to 173,000 awarded by US universities and colleges in that year. Table 1 shows that the European and UD regions would have to combine their potential human resources for science and engineering (B.S.degrees) to match those of the Asian region.

It is also to be seen that European and Asian institutions award a higher percentage of all their undergraduate degrees in NS&E fields than U.S. universities and colleges. About 30 percent of first university degrees awarded by institutions in EU countries are in the natural sciences and in engineering; about 15 percent of U.S. degrees are in those fields.

In 1992, doctoral degrees awarded in NS&E fields by Western and Central European institutions totaled more than 25,000, 38 percent above the U.S. level, and more than twice as many as the number recorded for Asian countries (Table 2). Like the United States, a large percentage of European doctoral degrees are earned by foreign students.

Table 1 – First University Degrees in Science and Engineering by Region

Field	United States	Europe	Asia
Total first university degrees	1,150,072	1,004,493	1,725,323
Natural sciences & engineering	173,099	299,057	523,651
Natural Sciences	111,158	140,126	242,879
Engineering	61,941	158,931	280,772
Social Science	182,166	116,353	236,018

Source: Human Resources for Science & Technology: The European Region NSF 96-316

Table 2 – Doctoral Degrees in Science and Engineering by Region

Field	United States	Europe	Asia
Total science & engineering	25,184	29,540	11,767
Natural science & engineering	18,251	25,310	11,223
Natural science	12,555	18,951	6,593
Engineering	5,696	6,359	4,630
Social science	6,933	4,230	544

Source: Human Resources for Science & Technology: The European Region, NSF 96-316

Western European invested about 2.1 percent. Western European civilian research, however, approaches that of the United States.

In addition, the amount of funds—approximately \$20 billion in 1992—spent on research performed at academic institutions in Western Europe now equals that spent at U.S. universities and colleges. Several Europe-wide programs are now in place to develop and improve S&T cooperation among the countries of the region. In particular, the EU is encouraging greater cooperation across borders to leverage S&T resources and maximize their productivity.

A free printed copy of the full report on this can be had from Dr Jean M Johnson, NSF, Division of Science Resources Studies, 4201 Wilson Boulevard Suite 965, Arlington, VA 22230 or sending e-mail to Pubs@nsf.gov. [*Data Brief*, NSF, November 27, 1996]. □

DSRM

Ultrasonic technique for gas measurement

A solid-state unit designed for monitoring the gas flow in a meter using ultrasonic technology has bagged the prestigious British Royal Academy of Engineering 1995 Mac Robert Award for innovation in engineering.

The gas meter was developed by the British Gas Research Technology and Gill Electronics Research and Development. The gas meter is monitored by a technique that involves ultrasonic frequency in the range of 100 kHz pulsed each second in either direction. The signals are timed and the difference between these times is a measure of the amount of gas flowing through the meter.

The new ultrasonic gas meter achieves a high timing accuracy of better than one billionth of a second and assures long-term accuracy and reliability, will detect any variation of irregularity in gas flow, e.g. interruption of gas supply or meter tampering. It measures only 220 mm x 120 mm x 75 mm deep and hence lends flexibility in housing it in confined areas. It has the potential for simple electronic additions to perform such functions as remote meter reading, perhaps via modem, and smart-card applications for gas prepayment. There is a provision for automatically shutting off the gas supply in any potentially hazardous situation.

The meter is extremely reliable and accurate under all anticipated conditions and for all forms of natural gas. Eurometers Ltd. will manufacture about 450,000 meters a year in a high volume production plant.

The technology used in the new gas meter could be adapted to other applications such as wind measurement instruments and in monitoring the breathing of premature babies [*Electron Today*, July 1996, p. 30]. □

DSRM

"Talking Labels" to be tried on pesticide products packings

Most of the products be it a bottle of medicine, or a pesticide, contain a label for the consumer to read application or usage instructions with cautions, if any.

It is observed through surveys conducted in USA that most consumers using pesticide products in their homes do not read labels. Even it was noticed that trained agriculturists also do not read the labels on the larger containers and apply too little or too much of the chemicals.

Toxicologist, Laura Dye of the Office of Pesticide Programs (OPP) used to receive reports annually of home explosions from misuse of pesticide foggers. In mid-1995 Dye taking a clue from an idea from the aquatic biologist, Alvaro Yamhure, also from OPP began trying the idea of developing "talking labels" on containers of pesticides that will verbally point out significant hazards associated with a product otherwise ignored by the consumer. The final prototypes are to be patterned after the talking chips in Hallmark cards greeting cards and have been developed by ISD, a San Jose, California computer manufacturer.

One prototype is a round chip that can be attached to the lid of the fogger bottle while the second one is a base ball card-size chip attached to the instruction booklet for agricultural pesticides. An information chip attached to a 3M dust mist mask is also under development. These chips are designed to draw the attention of the user to read the label attached to the box or can. It will be quite sometime that such products make their appearance in the market. The relevant policy, regulatory and compliance issues are likely to be discussed by the Environmental Protection Agency (EPA), USA. [*Environ Sci Technol* 31 (1) (1997) 12A].

DSRM

Technologies for rural applications

ER&DC, Trivandrum, under the control of DOE claims to have developed something like 67 technologies that have been transferred to industry. The Director, Dr Kulkarni, says that his institute is able to generate the required funding mainly from internal resources. According to him, only 30 per cent of the funding comes from government and the balance of 70 per cent is self-generated.

A Flasher buoy for the fishermen, coconut weevil detector and a fish finder are some of the rural electronic products developed by the organization. The technology for fish finder was developed in-house, but combining it with the Global Positioning System (GPS), the satellite based technology used for navigation purposes turned out to be a unique product - an ideal example for a developing country to press into service the latest sophisticated technology to the common man's needs. The Department of Ocean Development has agreed to test market the fish finder. DOD has indicated the locations, all over the coast, west as well as east, where these fish-finders will be grouped in six or seven areas, and will be installed on co-operative fishermen society boats.

ER&DC has also developed an electronics based energy meter. There is a heavy demand ranging over lakes for these metres and the electromechanical type are predominantly in use as their cost is many times less than the electronic ones. But ER&DC developed an electronics based meter costing less than Rs.1000 (as compared to Rs 600-700 for the electromechanical ones). The meter, it is claimed, consumes much less energy, besides being pilfer-proof and automatically detects tampering.

Another area in which ER&DC is working concerns with a number of energy management systems manned by various state electricity boards. Approached by the Panjab State Electricity Board (PSEB), ER&DC has developed a technique to selectively switch off agricultural pump sets. Due to the simultaneous use of a huge number of pumps by farmers, PSEB had a problem of overloading and the consequent burning out of 25 per cent of their transformers in Panjab. The ER&DC solution for this problem is to try a pager-based system in which each pump is linked to a pager. If the SEB wants to switch off the load of a pump with a particular farmer, it has to send a message to his pager, the pager converts this

message into a relay output, and switches off his pump. When the SEB wants to allow him to use his pump, another message is sent to the pager attached to the pump and it automatically switches it on.

ER&DC is engaged with some other projects for foreign parties also. AT&T has given it a contract for developing a part of the MPEG-II encoder. It has done some software projects in Indonesia, Saudi Arabia and UK. It has proposed to take the following four projects with Uzbekistan: One for the textile industry, one for the paper industry, one for the boiler and power industry and one for multimedia. These four projects are also in the pipeline.

The ER&DC is planning to concentrate in three or four areas to generate additional revenues, viz. Control instrumentation; Information highways; Multimedia and Software export business, particularly the hi-end of the software technology market. [*Electron Today*, 27 (11) (1996) 37-38]. □

DSRM

Energy technology goes 'green'

A team of researchers from University of California and Princeton University are exploring the possibility of converting light into electrical energy that uses a mechanism much resembling to that of the photosynthesis occurring in plants. Similar efforts using solid state devices are a lot less efficient still although research is going on in this field for increasing the efficiency.

The team is experimenting with materials called 'Chemiphylls' in keeping with their mimicry of chlorophyll process. It is a stable preparation that binds a layer of electron-donor substance (papd) to a layer of an electron acceptor substance (pv). The donor can be grown as a true film without crystalline structure while the acceptor pd forms extremely small crystals that can be neatly arranged in arrays in layers one molecule deep. Both papd and pd consist of an active core sandwiched between structures called phosphonates. Atoms of Zr bind to the phosphonates, tying the assembled 'sandwiches' to one another.

When illuminated with light, electrons move from the papd to the pd, creating an electric potential. A continuing one-way current can be maintained by providing an appropriate receptor material on the other side of the surface.

The researchers feel that while the chemophyll action cannot be used to directly power a device like radio or a hair dryer, it could be exploited in earlier trials to act as an effective power source for light induced chemical reactions such as breaking down water into hydrogen and oxygen or making natural gas out of the carbon in carbon dioxide to create clean-burning fuels.

Use of chemophyll material enables to deliver energy evenly throughout an entire surface of arbitrarily large size. Also it can be applied as a coating to an irregular surface. The photovoltaic action—unlike Si cells—is a wet process working in an electrolyte solution conducive to chemical reactions. It can be made to float on top of a liquid that would form the raw material for the chemical reaction. Further details can be had from: Mark Thompson, Associate Professor, Department of Chemistry, University of Southern California, Los Angeles, CA 90089-0744, Fax: (213) 740-0930; e-mail: mthompso@Chem1.usc.edu [*Electron Wrld*, 102 (1996) 449]

DSRM

Replacement of hydrogen for fossil fuels

Hydro Quebec, a north American Company, the Quebec government and Quebec industries have committed themselves to the Euro- Quebec/Hydro-Hydrogen Project with European industrialists as their partners.

The specific objectives of this project are to develop modes of transportation—cars, buses, planes—that will run on hydrogen or hythane, and to design appropriate infrastructures- containers for transporting the hydrogen, specialized tank, etc. Hydro-Quebec is responsible for the overall management of these projects and takes an active part in some of them.

The project is designed to proceed step by step to take care of this environmentally friendly energy source to protect the environment. During this project, the partners were asked to develop a prototype that runs on hythane—a mixture containing 20% hydrogen and 80% natural gas. Hythane produces 43% less nitrogen oxides (NO_2) than natural gas. Since 1995, two buses running on hythane have been in commercial use in Montreal, carrying passengers on two busy city routes. Over the next 12 months, other demonstrations are scheduled in Europe and in the United States. In the long term, i.e. 20 years

hence, it is expected that buses and automobiles will be running on all- hydrogen fuel cells, whose efficiency is twice that of internal combustion motors.

Similarly the possibility of launching a car fueled by hythane is being explored. In the field of aviation, development of airplane motors fueled by hydrogen is taken up in cooperation with the companies Pratt and Whitney, and Deutsche Airbus.

Regarding the transportation of hydrogen, new containers have been developed for liquid hydrogen that slice 50% off the transportation and storage costs. Once this technology has been certified, it is planned to build a manufacturing plant in Quebec.

A significant breakthrough was made with the development of new ultra-lightweight alloys which store hydrogen in the form of hydrides in record time and up to 6.6% by weight of hydrogen. It is hoped that within 5 years the process will allow hydrogen to be stored on board vehicles without any danger. Research is focused on materials for reversible electrolysis of water. Also, a study of materials for polymer electro type fuel cells has been taken up. [*Report of Activities 1995, Technology Key Results, Hydro-Quebec, 75 boul-Rene-Levesque Ouest, Montreal (Canada), 1995, p. 56-57*]. □

DSRM

Novel molecular technique to detect pathogens at workplace

Laboratory Workers are subjected to serious health risks by their occupational exposure to micro organisms. Many people run the risk of having cancer attributable to workplace chemicals. This requires a sensitive detection and precise identification of them to achieve efficient health control and occupational hygiene.

The conventional technique of culturing microorganisms in order to isolate and identify them have some limitations. Some pathogens are unable to grow, or grow extremely slowly in such conditions. The culture itself may pose a hazard to the laboratory worker.

Dr Jennifer Sherwood Higham, a senior scientist at the US Health and Safety Laboratory and her colleagues at Sheffield-based laboratory have been looking at various molecular techniques to replace the conventional culture method. During their research, they have studied a novel molecular technique that can target unique sequences on the DNA

blue print of a microorganism, which is likely to become the new 'gold standard for detecting and identifying pathogens in the workplace'. The new method allows more sensitive, specific, and rapid detection and identification regardless of the sample type.

Already this technique has been studied in identifying the possible risks of anthrax, which caused many infections early this century in textile and leather works [*Chem Brit*, 32 (11) (1996) 14]. □

DSRM

Word processing for mass spectrometry

Alan Marshall *et al.* of Florida State University, Tallahassee in collaboration with Melvin Comisarow and his colleagues at the University of Columbia have developed a method of interacting with mass spectrometer so that they can study tiny amounts (as little as a millionth of a gram for a 100 molecular mass compound or 10^{-15} mol) of medically important biochemicals such as peptides, complex sugars, and nucleic acids.

Identifying individual peptides for diseases such as cancer and multiple sclerosis may lead to vaccines for such diseases based on easy-to-make compounds.

Identifying the complex sugars found on the surface of the viruses may also help in the search for new drugs. The main problem in identifying these biochemicals is that they are found in only very tiny amounts in experimental cell cultures.

Researchers have developed a non-destructive mass spectrometer; the ion fragments are held away from the detector plate in a rotating magnetic field and measurable signals are 'induced' in the plate.

According to Marshall, however, it can take many attempts just to optimize the ionization sequence using this method; so sample is still wasted. He adds that once optimized, however, a clearer spectrum can then be built up by recording the spectrum repeatedly and averaging the result to reduce noise.

Marshall has compared the limitations of present optimizing processes to typing. Each tweak to change the ionization and excitation of the ion fragments is like a word, and a sequence of commands is like a sentence.

To change just one word, one has usually to retype the whole paragraph, hence the waste of sample. Often very little sample is left by this change, he and his colleagues have developed an interactive spec-

trometer that allows them to carry out the optimization process without wasting sample (*Anal Chem*, January 1997, p.1). Their spectrometer is more like a word processor, allowing them to change a word or even a letter halfway through a run and see its effects without having to retype the whole page.

To get the best spectrum one can tweak the commands, change the pressure inside the machine; and change the excitation frequency of the ionizing radiation, its amplitude and duration using separate commands. One can also check the effects as he proceeds by taking a snapshot spectrum at each step. Marshall's system can be controlled by software rather than hardware, which cuts costs as well as making it more adaptable. It will be certainly commercialized, since the method involves existing hardware and only minor new software changes [*Chem Brit*, 33 (No. 3) (1997) p. 19]. □

HKK

Many bands make light work

Researchers at the Bell Laboratories, New Jersey, USA have developed a single laser that may in near future send separate streams of digital information to at least 200 homes on an optical network.

They have split the light from one laser into signals at a record 206 different wavelengths. Each can act as a separate channel directed to a different place. And each channel can carry 37 million bits of data per second.

The Bell scheme tackles a key problem in developing fibre-optic services for homes the relatively high cost of laser transmitters.

The system begins with a laser formed by a ring of optical fibre doped with the rare-earth element Erbium, which emits light across a 70 nm range of wavelengths near 1550 nm in the near IR. This is the part of the spectrum where optical fibres lose the least energy when transmitting a signal. The laser generates 37 million pulses a second.

These pulses are then passed through a coil of optical fibre 20km long. As the speed of light along a fibre differs slightly with wavelength, the longer wavelengths lag behind the shorter ones, spreading the spectrum out along the length of the fibre. The faster wavelengths in each pulse arrive 20 ns before the slowest. A device called a modulator sits at the end of the fibre and switches rapidly on and off to slice the pulse into 206 narrow bands.

The modulator has another important function. It allows each narrow-wavelength pulse either to pass or not, and thus encodes digital information, such as a TV programme, for each wavelength.

The pulses then pass through a passive optical system, which sends each wave-length, and the signal it carries, to a different output port. From there, each signal can be sent to a separate home [*News Sci*, 153 (No. 2072) (1997) p. 22]. □

HKK

New generation PE technology rivals metallocene catalyst

Nova Chemicals, Calgary, Canada have made a breakthrough in polyethylene technology that will challenge metallocene resins.

The technology called Sclairtech technology uses a new solution-phase multi-reactor, which can be customized for specific applications, together with an advanced, high performance Ziegler-Natta catalyst. This combination provides high efficiency and advantages in capital and operating costs, product quality and environmental management.

The Sclairtech technology has been tested with various products including high density polyethylene (HDPE), linear low density polyethylene (LLDPE) and very low density polyethylene (VLDPE). The 'supercharged' reactor is designed to be used to produce customized resins for specific applications, including film, extrusion coating, moulding applications, pipe coating, geomembranes and non-woven applications. The resulting polyethylene (PE) resins are as good as or better than metallocene PE resins in many applications over 0.905 density. One key

benefit of the advanced Sclairtech resins is that they can be processed on existing equipment without the need for blending under high pressure or with other resins. They also offer an advantage in processing speed over metallocene catalysts.

While Sclairtech has so far only been tested using Nova's new Ziegler-Natta catalyst, the technology is also designed to use numerous other catalysts including metallocenes.

Unlike the complex patent position that is hampering the exploitation of metallocene catalyst technologies, several companies have interlocking patent claims—the advanced Sclairtech technology was developed in-house and will be free of legal encumbrance. Nova Chemicals having polyethylene capacity of 1.1 m tonne/y worldwide, plans to offer this technology for licensing to other petrochemical producers around the world [*Chem Brit*, 33 (No. 3) (1997) p. 19]. □

HKK

Flux helps metals to achieve a touch of glass

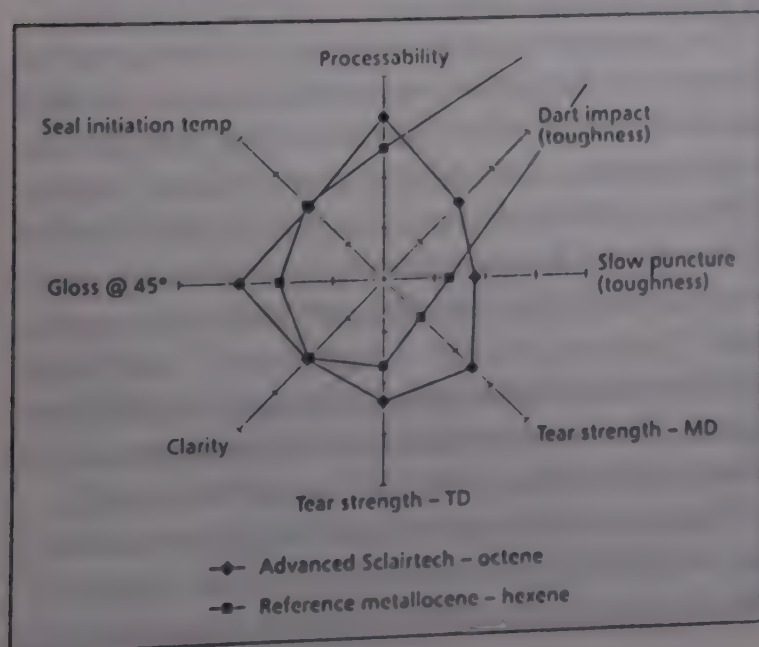
According to material scientists at the Los Alamos National Laboratory, New Mexico, glassy metallic alloys can now be made commercially. These metals are stronger than normal crystalline metal and more resistant to corrosion.

So far these could only be made as thin films. The process for forming bulk glass out of metallic alloys could be a boon for energy companies, because metallic glass conducts electricity much better than crystalline metals.

The metallic glass is a molten metal that has been cooled below its solidification temperature, making it viscous enough to maintain its shape for long. In a glass the atoms are not arranged in a regular way, unlike glassy metallic alloys.

Production of metal glass in huge quantities or pieces was earlier impossible because of the presence of impurities in the liquid metal, which prompted crystallization.

Ricardo Schwarz of Los Alamos Laboratory has overcome this problem by using a flux, a mixture of oxides with a relatively low melting point that will not dissolve in the liquid metal from which the metallic glass is to be made. When melted and mixed together with the metal, the flux draws out the impurities. The flux and its cargo of impurities then separate from the metal as the mixture cools below the



temperature at which the metal turns to glass. The process is used to treat alloys of three or four metals, such as Pd, Ni, and Cu.

The strength and corrosion resistance of metallic glass are a consequence of its lack of crystals. In a hunk of solid metal, corrosion often starts at the boundaries between neighbouring grains of crystals.

The experiments show that glasses are more efficient conductors of electricity than crystalline metals. It is estimated that if all the transformers in the US electricity distribution network were replaced with one made of metallic glass, more than \$1 billion in energy lost would be saved each year [*New Sci*, 153 (No.2067)(1997) p.20]. □

HKK

Coated windows allow the sun shine in

Dieter Sporn *et al.* at the Fraunhofer Institute for Silicate Research, Würzburg, Germany, have developed new anti-reflective coatings that make it possible to treat windows and solar collectors so that more light comes in than even the finest of presently available optical instruments.

Ordinary glass reflects about 8% of sunlight in the visible spectrum because of the large difference in the refractive indices of air (1.00) and glass (1.51). Optical glasses and camera lenses are coated with an alternating series of films of high and low refractive index. These set up an interference pattern that prevents incoming light from being reflected. But these are quite expensive, both literally and optically and are too costly for large surfaces and prevent some of the light from getting through.

The coating made of silicon dioxide has been developed which creates a porous covering on the glass. The glass is dipped in a coating solution of silicon dioxide and then baked at 500°C. The coating looks like a sponge comprising a silicon dioxide framework riddled with pores about 15nm in diam. Because these microstructures are much smaller than the wavelength of visible light, the light enters the coating as if it were simply air. The silicon layer has an effective refractive index of 1.22". This means that for visible wavelengths, 99.5% of light is transmitted, while about 97% of the solar spectrum passes through.

The first application is expected to be in solar energy. Solar collectors presently use ordinary glass that reflects over 9% of the incoming energy and

cutting this loss to about 3% will mean a big gain in efficiency at very low cost [*New Sci*, 153 (No. 2065)(1997) p.21]. □

HKK

First evidence that ozone hole harms antarctic fish

Researchers supported by the National Science Foundation (NSF) have presented the first direct evidence that increased ultraviolet light (UVB) damages the DNA of animals in a natural population in Antarctica-- the eggs and larvae of icefish, an Antarctic fish lacking hemoglobin. The ozone hole opens up over Antarctica every southern spring, letting more UVB from the sun penetrate to the earth's surface.

In an article published in the February 17 issue of the Proceedings of the National Academy of Sciences, biologists from Northeastern University and the University of Texas demonstrated that icefish eggs accumulate significant levels of DNA lesions called cyclobutane pyrimidine dimers.

The scientists were surprised at the extent of the DNA damage although they are eager to know what happens during the rest of the year when the ozone hole closes up.

Ozone depletion has previously been shown to harm one-celled marine plants in Antarctica. There is documented significant damage at a higher level of the food chain. It was striking how closely the damage to the fish eggs tracked with the increased intensity of ultraviolet light.

The studies were done on cruises in waters around the Antarctic Peninsula, the finger of land that juts up toward South America.

The protective ozone layer over Antarctica has thinned over the past two decades, as human-created chemicals called chlorofluorocarbons have risen to the stratosphere and helped to destroy ozone. Antarctica's ozone levels typically drop to less than half of normal during the spring ozone hole, allowing wavelengths of sunlight harmful to life to penetrate to the earth's surface and into ocean waters. The ozone layer has also thinned, although less so, in temperate regions. Ozone depletion is predicted across even broader area of the globe over the next century.

The excess ultraviolet light may slow a fish's growth, hamper cellular processes such as transcription and mitosis, and divert precious energy to DNA

repair. Increased UVB may ultimately let fewer survive to adulthood.

The biologists also found that animals vary in how fast they can repair damage to their DNA. Organisms such as icefish and krill, which breed in spring and release their eggs into ocean waters at the peak of the ozone hole, can repair DNA more than twice as fast as rockcod and other fish that breed in winter. Scientist believes that animals that breed in spring and summer when the sun is out "are a little better prepared by nature to face the ozone hole."

The researchers' next step is to explore whether the DNA damage actually does hamper the animals' ability to survive. In any case, key members of the Southern Ocean food web such as larval and adult fish, krill, copepods, and some zooplankton—the food base for seabirds, whales, and seals - could all be vulnerable to increased UVB [*NSF-PR 97-19*, March 11, 1997].

New TB vaccine must have larger trials

An injection of killed *Mycobacterium vaccae*, a microbe commonly found in soil, improves the chances of recovery in people with TB. It is believed that the drug works by boosting the immune responses to *M. tuberculosis*, the organism that causes TB. But further trials are needed before hopes are raised too high.

John Stanford and his colleagues at Stanford Rook tested the method on 102 Romanian TB patients who had not been cured by the standard drug treatment. Half the patients received a single injection of the killed *M. vaccae* one month after a new course of drug treatment had begun. The other half received a placebo injection. A year after the start of the drug treatment, 97 per cent of the group who received the *M. vaccae* injection were free of disease, compared to 70 per cent of those who had the placebo. But other researchers have expressed their concern that patients in these trials were not allocated completely at random to receive the treatment or placebo, raising questions about the conclusions made from these studies.

The therapy probably works by boosting a class of T helper cells in the immune system, known as Th1 cells, which help to kill off bacteria in infected cells. Studies regarding monitoring a controlled, randomized trial of the treatment in 372 TB patients being run by the South African Medical Research Council

in Durban, with independent statistical assessors are being carried out now to establish the usefulness of the drug [*New Sci*, 153(2074) (1997) 19]. □

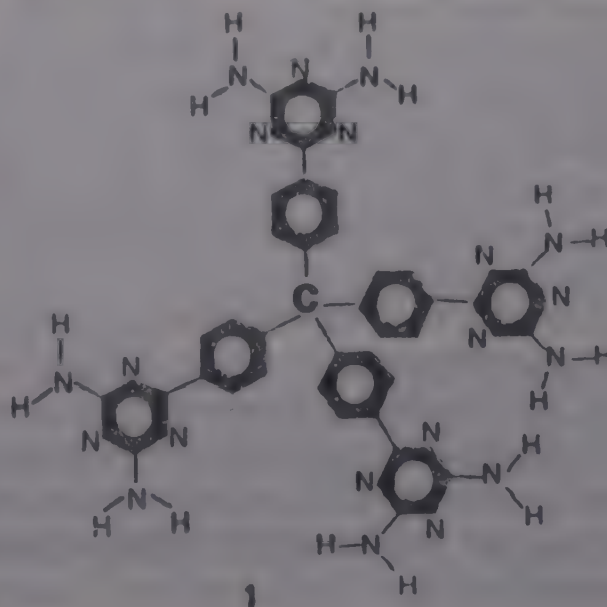
CSG

Cooperative bonding affords robust porous crystals

New crystalline solids would affect areas as diverse and commercially relevant as catalysis, materials science, chemical separation and drug selection. In the context of separation, the terms 'open framework' and 'molecular sieve' have become synonymous with porous inorganic networks, in particular the class of aluminosilicate networks, commonly called zeolites.

The metal-organic polymer frameworks can sustain channels of cavities that are as large as or larger than those found in naturally occurring zeolites. Furthermore, these new porous solids remain intact even after the partial loss of guest molecules such as benzene and pyridine. Wuest and his co-workers have synthesized an unlikely new member of this exclusive but growing class of compounds, an organic molecule **1** that self-assembles to form a porous, three-dimensional, hydrogen-bonded network. The molecule **1** (shown in figure) is pseudo-tetrahedral, with many complementary hydrogen-bond donors and acceptors on its periphery. It self-assembles to afford a hydrogen-bonded network having unusual properties.

The molecule crystallizes into a hydrogen-bonded framework of sheets that contain roughly square cavities, about 11.8×11.8 Å. These sheets crosslink, again by multiple hydrogen bonds, so that the cavities eclipse one another. The result is that the cavity



becomes an infinite microchannel. The inner walls of the channel contain the excess hydrogen-bond-donor sites present on the molecule. So they efficiently bind solvent molecules such as 1,4-dioxane, acetonitrile and water. The crystals lose solvent under vacuum, but retain their crystalline form even after losing 66% of the dioxane molecules.

Most remarkable feature of the new molecule is the hydrogen bonds strong enough to sustain such a large amount of open space in a crystal. The key to the robustness of the network formed by **1** is due to multiple hydrogen-bonding sites providing enough mechanical strength to withstand the loss of a considerable portion of the contents of the crystal lattice. Similar stability is observed in the covalently bonded zeolites, and it is critical in catalysis and filtering because it makes adsorption and desorption of guest molecules a reversible process. Multiple hydrogen bonding sites are also used for structural control and molecular recognition in important biological molecules such as DNA and proteins.

Crystal engineers are not yet able to rationally design molecular sieves for organic molecules of industrial and environmental relevance. But the new work makes it clear now that crystal engineers are not limited by the chemical nature of species or the strength of the individual bonds that can be exploited to sustain porous networks [*Nature*, **386** (1997) 220]. □

CSG

First ever mammalian clone produced from sheep

The first mammalian clone, Dolly (a 6-month-old lamb cloned from the udder cell of an adult sheep), has been produced by Ian Wilmut and Keith Campbell at the Roslin Institute in Edinburgh, Scotland. Even though animal scientists have been cloning sheep and cattle from embryos for a decade, the media went wild over Dolly, the first animal ever cloned from an adult cell.

The cloning of Dolly has been done by transferring the nucleus from an udder cell into an egg whose DNA had been removed -- an approach that could lead to flocks of prize animals with a genetic makeup guaranteed to match that of the adult donating the cell or of animals that produce valuable human proteins for therapeutic use.

But the procedure is quite inefficient. The Roslin group made 277 attempts in order to succeed with Dolly. And no one knows either how DNA from the udder cell was able to direct the development of an entire new organism, or whether the same will prove true in other species.

Up to now, a great deal of evidence has indicated that while species ranging from frogs to mice to cattle and now monkeys can be cloned by transferring nuclei from embryonic cells, the DNA of older cells is irreversibly altered.

During the studies, DNA of donor cells behave more like the inactive DNA of a sperm or unfertilized egg. It was done by reducing the nutrient-laden serum supplied to the cells, in effect starving them into the dormant G0 or G1 stages of the cell cycle. The deprivation caused many genes to shut down and ensured that the DNA had not just replicated when it was transferred. The researchers then administered an electric current to fuse this donor cell with an egg whose own chromosomes had been extracted.

The fusion provided the egg with a full complement of new DNA and triggered the development of the egg. The first three divisions of the sheep egg replicate its DNA without expressing any of the new genes. Proteins and messenger RNAs already in the cytoplasm do all the work required for division. While the DNA goes along for the ride, it loses the proteins that come attached to it and takes up others from the cytoplasm. At the same time, it apparently becomes "reprogrammed" so that the embryo can develop normally.

The multiple replications, and the several days it takes for them to occur, may be the reason nuclear transfer works in sheep but not very well in mice. In mice, all DNA remodelling takes place in the first cell division and the new DNA takes over by the two-cell stage, rather than in the eight-cell stage as in sheep. In humans embryos, the new DNA apparently takes charge after the four-cell stage, in between mice and sheep or cows.

Or it may be that Dolly's DNA didn't require much reprogramming as it came from cultured mammary cells, which are normally capable of developing into lactating tissue. Wilmut and his colleagues acknowledge that the collection of cells may have included a stem cell -- an undifferentiated progenitor cell of many different tissue types -- which has a

higher developmental potential than an ordinary epithelial cell from the mammary gland.

But assuming reprogramming did occur, its efficiency is quite low as the sole successful transfer took out of 277 attempts. Efforts to increase that success rate may run into another barrier as it is not known how programming occurs normally during development. This makes understanding deprogramming difficult, although it likely involves reversal of chemical modifications, such as methylation and acetylation, that the DNA and its associated proteins undergo as cells take on specialized functions. Also, some reprogramming may occur when DNA is stripped of its old packaging proteins and repacked with new ones in the egg's cytoplasm -- a process that also occurs with the DNA of a fertilizing sperm.

It may now be possible to study how programming occurs by examining the molecular conversation that goes on between the egg and the transferred nuclei. And the reprogramming is just one aspect of cloning that can go wrong. Many subtle differences exist between mammalian species in how they develop during those first few days. Not only do they differ in how quickly the new DNA takes charge, but they also vary in how they decide to implant in the uterus and develop a placental connection. These differences could make nuclear transfer from adult cells harder, if not impossible, in animals other than cows or sheep. [*Science*, 275(5305) (1997) 1415]. □

CSG

Vacuum cleaner gets to the roots of asthma

Charles Naspitz and his colleagues at the Federal University of Sao Paulo, Brazil have found that the skin flakes on children's scalps provide a comfortable and overlooked refuge for house-dust mites, which trigger allergic responses that can cause asthma attacks.

Naspitz *et al.* studied children from middle-class households whose general standards of hygiene were "satisfactory". Using a household vacuum cleaner with a fine nozzle they collected fine dust from the children's scalps, just hours after they washed their hair with an ordinary shampoo.

Two common species of mite, *Dermatophagoides pteronyssinus* and *Blomia tropicalis*, were found in the scalp dust. The children had similar numbers of mites on their scalps whether or not they had asthma. But blood tests showed that while the

asthmatic children made antibodies to them, the non-asthmatic children did not.

It is found that scalp is an ideal home for mites. Conditions there are warm and humid, and the mites can feast on the skin flakes. It is argued that may parents' efforts to keep mites under control, e.g. by vacuuming mattresses and putting pillows into the freezer, may have failed because no one thought to banish them from children's scalps.

It is thought to be an interesting observation. Neither Stephen Durham of the National Heart and Lung Institute nor the Brazilian team recommends vacuuming children's heads to keep the mites under control. Instead, parents should try using an antidandruff shampoo to keep the number of skin scales down [*The Lancet*, February 1997; *New Sci*, 153 (No. 2069) (1997) p.5]. □

HKK

Narrow arteries fail Indian hearts

Veerendra Rathmore and his team at the Birmingham City Hospital, UK, have shown that people from the Indian subcontinent have narrower coronary arteries than white Europeans. This may help explain their unusually high risk of developing heart disease.

The team has examined the angiograms of 27 cardiology patients from the subcontinent, and 59 white patients. The average coronary artery diameter of the first group was found to be 24.32mm against 26.15mm for the white patients. The difference is small but significant. "If you have a clot of a certain size in the coronary arteries of two people, and one has a narrower artery than the other, that person is more likely to have a blockage, and a heart attack" says Rathmore.

Other suspected risk factors in South Asians are high blood cholesterol, unusual lipid biochemistry and a genetic predisposition to develop diabetes. These factors should still be considered. But narrower arteries are an independent risk factor and could help explain why people from the subcontinent experience more coronary artery disease than other ethnic groups.

It is also suggested that people from the Indian subcontinent who have coronary artery disease may need different types of surgery. Their arteries may be too narrow to be treated with stents — pipe-shaped devices inserted to support arteries. Instead, the best treatment would be balloon angioplasty, where an

inflatable balloon on the end of a catheter is used to dilate vessels [*New Sci*, 153 (No .2069) (1997)p.18].

□

HKK

Honours and Awards

Mullard award for 1996 of the Royal Society has been bagged by Scientists of Pilkington, Ian Mckittrick, Edward Hargreaves and Michael Jenkins for their development of a new energy-saving glass. The award carries a silver gift medal and a prize of £ 2000 for outstanding contribution to the advancement of science, engineering or technology leading directly to national prosperity in UK.

Pilkington K Glass is used as the inner pane of a double glazed unit and has an ultra-thin coating made of a silica-like material that traps solar heat and radiated infrared wavelengths inside the building, thus conserving energy and reducing heating costs. Central to the successful manufacture of the glass are the technology required to coat the glass evenly and the custom- designed exhaust gas clean-up systems to protect the environment [*Chem Brit*, 32 (11) (1996) 13].

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DSRM

Highlights of BEL research programme for 1996-97

Bharat Electronics Limited (BEL) has been steadily improving its performance year after year. The equipments exported during 1996- 97 include: X-ray tubes to GE Medical Systems, Singapore; Spherical X-ray radiation monitoring equipment to General Electric Medical Systems, USA; Radar sub-systems for Oerlikon-Contraves, Switzerland; Communication equipment to Malaysia; Optical components to Israel; Surgical microscopes to Egypt, Saudi Arabia and Malaysia, etc; Surface mount semiconductor devices to Singapore; Broadcast and TV transmitters to Vietnam and Brazil; and Semiconductors/ICs to Hong Kong and Singapore.

The systems being manufactured presently by BEL are: Radar systems; Communication equipment and microwave components; 'Tank' electronics; Electronic warfare equipment; TV glass shells and optical equipments; X-ray tubes; Special batteries; and Laser range finders.

The new products developed for Civil Sector include: Fish finder for locating fish and providing navigational guidance for fishermen; 'Conquest' energy saver for saving electrical energy when connected to an air conditioner or any similar thermostatically controlled unit; Alarm system for unmanned level crossing; VHF radio based universal emergency communication system developed for Indian Railways; Advanced multimedia satellite communications for voice, data, fax, and video using frequency and time multiple access; Security Facsimile to be connected between the FAX unit and the telephone line providing high grade security for FAX messages; and 1 kW FM transmitter.

The new products developed for Defence Sector include: VHF trans-receiver (25 W) with built-in encryption; Semi ruggedised automatic exchange; C (command, control and communication) systems; Composite communication systems (CCS) for naval applications; Digital universal control harness (DUCH) for tank communications; GPS (global positioning system); Electronic surveillance systems; Simulators and automatic test systems; Laser range finder; Sub-units of tank gun control systems; Active and passive radar for navigation and control; Air and surface surveillance radars; Low level detection radar; Secondary surveillance radar; Sonar and underwater systems [*Bharat Electronics Ltd*, New Delhi, 1997].

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CSG

Report of the Working Groups of Information Society Forum of the European Commission

The European Commission decided to set up the Information Society Forum in February 1995 in order to create a new and authoritative source of reflection, debate and advice on the challenges of the Information Society.

The Forum consists of 128 members drawn from five main fields of activity:

- ▣ Users of the new technologies: industry (banks' retail, maritime etc), public services, consumer groups, small and medium-sized enterprises and the professions
- ▣ Social groups: academics, employers organizations and trade unions, youth groups, regional and city representatives

- ▣ Content and service providers: publishers and authors, film and TV producers, broadcasters, computer software producers and information service providers
- ▣ Network operators: fixed telecommunications, cable TV, mobile and satellite operators
- ▣ Institutions: members of Parliament, of the Economic and Social Committee of the Committee of the Regions and the data protection Commissioner.

Six working groups have been formed whose members have given their views under the following heads the impact on the economy and employment;

- ▣ basic social and democratic values in the "virtual community,"
- ▣ the influence on public service
- ▣ education, training and learning in the Information Society
- ▣ the cultural dimension and the future of the media
- ▣ sustainable development, technology and infrastructure

The European Commission has published the first Annual Report and the supplementary report (working group's reports) which can be obtained from the Information Society Forum Secretariat (European Commission, Information Society Activity Centre, 200 Rue de la Loi, BU 24, 2/70, B-1049 Brussels. The full texts are also available on the ISPO web server at: URL: <http://www.ispo.cec.be/infoforum/pub.html>

Summary of the report of Working Group II under the head "Basic Social and Democratic Values in the Virtual Community" is given in this issue. The other reports of the Working Groups will be covered in subsequent numbers of JSIR one in each issue.

Improvement of Democratic Structures

The Working Group warns against the possible new division of society between the information haves and have nots and states: "While information technologies remain the preserve of a relatively wealthy, well-educated and privileged elite there will be a social and democratic deficit potentially damaging to the existing fabric of society". The Working Group believes that the development of networks and operating systems must enhance access and choice and must not exclude certain groups in society.

The Working Group demands adequate access for all to communications technology and insists that existing democratic structures should not be subject to undue influence of powerful groups with privileged access to media and technological resources.

"The speeding up of the political process may put increased pressure on representative systems. Government may become more reactive in style and less considerate of different views and interests. There is even a risk of commercialization of politics..

The Working Group says it is important to encourage a new commitment to public service provision.. "There is a need for local access points to on-line services with the potential to be user friendly".

Freedom, Quality and Reliability of Information

The Working Group says citizens' rights of access to public information should be guaranteed through common freedom of information laws in all member states of the European Union ... "where there is a need for harmonization of rules in this area it is desirable that the highest level of openness presently available in Europe should provide the basis for change".

Although the Working Group states that "existing laws and standards providing for freedom of expression and opinion and protection of cultural rights must apply to all information services made available for public consumption" there is recognition that "it may be increasingly unrealistic to believe that information flows can ultimately be controlled". This calls into question existing national legal standards which prohibit the dissemination of certain information, such as child pornography, racist material and information advocating violence.

The Working Group concludes that "freedom of choice for consumers requires that flexible and not intrusive systems of content control are necessary".

At the same time, new information services available on the open-market may not be sufficient to guarantee current standards of pluralism and "countries will have to consider whether new forms of public intervention are necessary".

Reliability and quality of information remain primary concerns. Content providers must be given support to meet the highest ethical and professional standards.

Privacy and Rights of the Individual

The Group finds increasing evidence of governmental interference in the area of encryption which may threaten the right to privacy. The Group insists that the right to privacy and the citizen's right to anonymity in their communications "is a matter of the highest priority and must be protected".

There is a need for rules to ensure that the right of people to encrypt their messages and communications is not diminished through compulsory systems of state control of encryption keys which may undermine the right to privacy. People must also be able to control growing private sector use of personal profiles in computer databanks.

"...the opportunities of the information society can be obtained without sacrificing individual liberties, particularly regarding privacy. Solutions can be found using the means of technology that have created the problem".

The Working Group finds that the Commission must help to define international standards to ensure that established European values are reflected in the reality of tomorrow's information society. "Emerging international standards must take fully into account data protection and privacy concerns". In addition, the conditions under which personal data can be collected and processed, as defined by the European Union Data Protection Directive, must be reaffirmed and further developed.

In future it will be necessary to examine how existing protection principles can be integrated into the technology under development. Information systems need to be designed to maximize the protection of data. Technology must restore anonymity.

Social and Regional Disparities

Questions of universal service must address the challenge of affordability so that individuals confronted with costs of equipment, connection, service subscriptions, and other usage costs can participate and must also ensure adequate infrastructure is physically available to all who require it, for instance for people with disabilities.

Above all, the Working Group believes the development of networks and operating systems must ensure all citizens, regardless of geography, social or economic status, have the opportunity to participate by providing basic services which address the needs of all sections of society. [First Annual Report to the

European Commission, from the Information Society Forum Secretariat, European Commission, Information Society Activity Centre, 200 Rue de la Loi, BU 24, 2/70, B-1049 Brussels].

Announcements

Golden Jubilee Congress and CHEMCON-97

Golden Jubilee Congress and CHEMCON-97 are being held at the Indian Institute of Technology, Delhi during 15-18 December 1997.

The Congress and CHEMCON-97 are being organized by Indian Institute of Chemical Engineers (North Regional Centre) in collaboration with Indian Institute of Technology, Delhi.

The Congress

The Golden Jubilee Congress and CHEM-97 are designed to bring together eminent and world-renowned chemical engineers from various fields, e.g. education and research and industry, to demonstrate to the world community the contributions made by chemical engineers and their commitments towards not only sustainable developments but also for enhancing the quality of life.

The programme will include prestigious Golden Jubilee and plenary lectures, keynote addresses and seminar presentations by invited speakers. Parallel technical and poster sessions of CHEMCON-97 will provide an opportunity to research scientists from universities, technological institutes and research laboratories to share their scientific findings and developments. A youth-oriented programme will also provide a suitable platform for the students of chemical engineering.

A comprehensive programme is also being formulated to bring into focus the inter-relationship of chemical engineering with other important and related disciplines.

Following themes will be included in the Congress:

1 Chemical Engineering and Sustainable Development

Safety, Health and Environment
Renewable Resource Engineering
Energy Conservation

2 Future Process Technologies

Food Processing and Agro-technologies
Biotechnology
Hydrocarbon Processing

**Petrochemicals and Polymers
New Materials**

3 Chemical Engineering Development

Modelling, Simulation and Optimization
Advanced Process Control
Computational Fluid Dynamics
Novel Separation Techniques

4 Chemical Engineering Science: New Frontiers

5 Process Industry in South Asia & Asia-Pacific Region

6 Vision 2010 and Beyond

Public Awareness Programme

A comprehensive and well-structured public awareness programme has been formulated and is to be published via the print and electronic media spread over the year. The focus is to highlight and deliver reliable and intelligible presentations about the contributions of chemical engineering in national and international developments in areas such as food production, environment management, health care, energy alternatives and conservation for enhancing the quality of life.

Call for Papers

Papers are invited on one of the identified themes and will be published as proceedings of the IChE Golden Jubilee Congress. The full paper is to be submitted directly, i.e. there will be no intermediate stage of submission of abstracts. The papers will then be peer reviewed. Submission of the full paper is a requirement for presentation at the Congress. Detailed instructions for the preparation of manuscripts may be obtained from Dr Sunil Nath, Editor, IChE Golden Jubilee Congress, Department of Biochemical Engineering and Biotechnology, Indian Institute of Technology, Hauz Khas, New Delhi 110 016, E-Mail: sunath@dbeb.iitd.ernet.in; Fax: 91-11-6862037 or 91-11-6868521; Tel: (off) 666979/2017, (Res)6857457.

For further details contact:

Dr P V R Iyer,
Department of Chemical Engineering,
Indian Institute of Technology, Hauz Khas,
New Delhi 110 016.

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HKK

Research and Advanced Technology for Digital Libraries

The first European conference on "Research and advanced technology for digital libraries" will be held in Pisa, Italy, from 1 to 3 September 1997. The conference is sponsored by the European Community's specific programme in the field of Training and Mobility of Researchers (TMR).

The aim of the conference is to bring together researchers from a variety of disciplines, whose work relates to the development of digital libraries. This should assist in the formation of a European research community in the field, and stimulate discussion and review of research underway, both in Europe and in the USA and Japan.

Topics for papers for presentation are:

- Digital library models, frameworks and system requirements;
- Information retrieval, organization navigation-tools and paradigms;
- Metadata;
- System integration and architecture issues;
- Role of knowledge representation systems in digital library interactions;
- Inter-operability, scalability;
- Networked information discovery;
- Collecting, capturing, filtering, cataloguing, indexing, preserving;
- User interfaces;
- Multilinguality;
- Handling of graphics, GIS, multimedia information;
- Intellectual property rights;
- Authoring and electronic publishing;
- Economic and social implications and issues;

The deadline for submission of preliminary papers is 15 May 1997.

For further information, please contact:

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Additions and Corrections**Vol. 56, April 1997**

Reference	As printed	To be read as
Page 220 (Abstract: 7th line)	T_2	T_{12}
Page 222 (2nd para, 8th line)	T_2	T_{12}

Vol. 56, May 1997

Page 249 (Title)	'Development'	Deployment
Page 249 (Line 32)	CC4DD	To be deleted
Page 254 Table 9, Col. 2, 2nd line in total; in Col. 2 below 39	$(.0022)$ $(.002)$	(0.22) (0.2)
Page 256 Table 11, 6th Col. in total; 9th Col.	$(.0008)$ $(.0062)$	(0.08) $0.62)$
Page 257 Table 12, under row total, Col.6 Col. 7	$(.002)$ $(.004)$	(0.2) (0.4)
Page 258 Line 3	taining	training
Page 272 and 273	COO_3^{2-}	CO_3^{2-}

Journal of Scientific & Industrial Research

(Incorporating *Research and Industry*)

Instructions to Contributors

The **Journal of Scientific & Industrial Research** (Incorporating *Research and Industry*) is published monthly to serve as an information link between the generators and users of technologies. It is addressed primarily to industrial entrepreneurs, technologists, engineers, technocrats and administrators in industry. Therefore, original research articles of practical interest to industry are invited for publication.

Contributions should have an economic bias, and wherever possible, cost estimates should be provided. They should be tersely written, giving only the significant results.

Besides, reviews on various branches of science and technology, science/industrial policy and management are also accepted.

Subject Coverage

Scientific Industrial Research

- (i) Scientific investigations successful at the pilot-plant and in-plant trials.
- (ii) Technology upgradation.
- (iii) Development of cheaper and indigenous raw materials as replacement for unecological materials.
- (iiv) Import substitution.
- (v) Technologies for rural development.
- (vi) Standardization and quality control.
- (vii) Technologies of waste management.
- (viii) Industrial R&D highlights.

Technology Management

- (i) Success/failure stories in technology management.
- (ii) Technology assessment.

(iii) Technology transfer.

(iv) Technology assimilation and adaption in different industries.

(v) Technology funding including venture capital.

(vi) Human Resource Development.

vii) Management.

(viii) Environmental management.

Industrial Development

(i) Policies, programmes and progress.

(ii) Critical profiles of industries—individual and sectoral.

(iii) Technology Forecasting .

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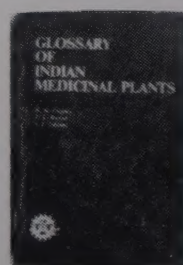
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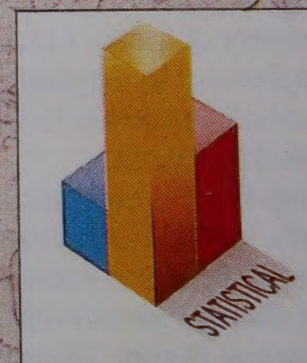
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